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SUSTAINABLE COMPOSTING OPTIONS

in the Province of Alberta

FINAL REPORT

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SUSTAINABLE COMPOSTING OPTIONS

CANADIANA

JUL 5 1995

Action on WASTE

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Preamble

Across Alberta many communities, both rural and urban, are addressing the issue of solid waste disposal as existing landfills are nearing capacity. The councils and respective administrations of these communities recognize the option of reducing or replacing their reliance on the common practice of landfilling with environmentally responsible alternatives. Waste transfer and regionalization have been successful in reducing the number of landfills in rural and urban Alberta. Concerted efforts are now being made through recycling and composting to reduce the amount of waste material being landfilled.

Compostable organic materials account for up to 70% of the waste generated by most communities in the province. Some of these wastes, such as cardboard and old newsprint, representing 40% of the average waste stream, are being recycled already where resources permit, but the economics of such programs can be difficult to justify if the community is not within easy reach of major recyclers. Composting is recognized as the viable alternative strategy for managing cardboard and paper waste that cannot be recycled, and is a primary strategy for managing the other 30% of organics which make up the average waste stream.

Study Purpose

The purpose of this study is to provide a report on the relative advantages and disadvantages of available composting options for the province, including a review of existing conditions and the actions required to make composting sustainable.

More specifically the study provides:

1. An assessment of the existing and potential feedstock for composting from domestic and commercial generators.
2. An identification of the most prevalent current and local issues associated with composting programs and operations.
3. An evaluation of the relative strengths and weaknesses of different composting options.
4. An identification of markets for compost produced in Alberta.
5. An identification of options for public and private sector action that may be necessary to support composting programs in Alberta.

Study Scope and Methodology

This study is limited to the identification and assessment of those composting options appropriate for rural and urban municipalities in Alberta. A review of programs existing elsewhere was largely restricted to Canadian and American communities where living conditions are similar.

The research methods employed involved primary research in the form of meetings with stakeholder groups (*i.e.*, provincial health officers, a major stakeholder workshop and telephone interviews with numerous industry and commercial sector generators) and secondary research involving in-depth literature reviews from throughout North America and more localized assessments of compost programs that have taken place in Alberta.

Care was taken to ensure that the identification of compost feedstock, generators of feedstock and the conditions surrounding the collection and processing of compostable materials were all representative of the variety of Alberta communities. In this regard data has been collected and analyzed for seven community models:

1. Village
2. Town (non-farming region)
3. Town (farming region)
4. Small City
5. Large City
6. Resort Community
7. Integrated Region

Study progress was monitored through regular meetings of the composting task force and the consultant group. The study took approximately six months to complete.

Composting

For the purpose of this study, composting is defined as an aerobic biological decomposition process which ultimately degrades organic material to carbon dioxide, water and a stabilized residue predominantly made up of humic substances called compost. Composting is carried out by the growth of microorganisms in organic waste. It can occur in nature, or it can be made in a more expedient manner by using a variety of mechanically assisted processes.

Since our waste stream in Alberta is comprised of over 70% organics, composting as an alternative to landfilling could become a widespread business or, at the very least, an integral part of every community's waste management program.

Perspectives of Sustainability

Composting in Alberta must be carefully pioneered as a sustainable activity which provides:

- *Social Acceptance* or the overall agreement of community residents to accept the impacts and ongoing responsibilities associated with the separation, collection and processing of organic wastes and to perpetuate the utilization of compost as a preferred soil amendment.

- *Environmental Compatibility* or the degree to which the activity recovers renewable resources in a safe and health conscious manner and utilizes them at rates which preclude their depletion.
- *Physical Feasibility* or the ability of an individual or community to recognize compostable feedstock, obtain it, process it and utilize its end products.
- *Economic Viability* or the ability to undertake composting at costs which are affordable to the individual or community.

Compostable Materials in Alberta

The compostable organics found in Alberta's municipal waste stream can be broken down into two major segments. One is comprised of paper related products like old corrugated cardboard and newsprint, which can make up as much as 45% of the waste stream. The other, a more diverse segment, makes up around 30% of the waste stream and is comprised predominantly of plant wastes, grass clippings and food wastes which originate in varying quantities from homes, businesses, industries and municipal operations.

These compostable organics, although always present in the waste stream, vary with respect to their ability to be obtained as compost feedstocks. Cardboard and newsprint for example, are readily recycled through established programs in most larger centres, while in smaller more remote communities these items may well be candidates for composting programs. Yard and food wastes, which are regarded as the most common composting ingredients of backyard composters and small scale municipal operations, represent the primary feedstock targets for most Alberta communities. Grass and yard clippings alone can represent close to 20% of most municipal waste streams and if diverted can have significant impact in reducing landfill volumes.

In addition to municipal, industrial, institutional and commercial organic waste, which represents 1.7 million tonnes annually, Alberta also possesses a much broader source of compost feedstock in the form of livestock manure from farming operations and wood residues from the logging industry. In fact, these two sectors combined account for close to 47 million tonnes annually, 30 times as much as municipal sector organics.

Programs and Options Suitable for Alberta

There are three essential ***levels*** of composting activity which apply across the province:

1. Composting at home, in the form of worm composting (indoors) or backyard composting (outdoors);
2. Institutional composting by a commercial organization, a farm or a closed community such as a hospital or prison; and
3. Community composting, which may occur on a variety of scales but necessitates organization and transportation at a higher level than an operation confined to materials that are collected and processed at a single site.

Home composting has been initiated and is continuing in some Alberta municipalities. This activity has been stimulated by recent municipal backyard composting programs which encourage participation through the provision of subsidized composters and associated training seminars. The success rate of these programs is yet to be determined. Although participation is small at this point, it is increasing and the ultimate sustainability of home composting programs will depend upon continued awareness, education and ultimately the measured success of the programs which are now in place.

The composting of waste can be undertaken utilizing a variety of systems, including:

- static pile composting, which can handle 50 to 1500 tonnes per year
- windrow systems, which handle up to 25,000 tonnes per year
- simple channel and tunnel systems, capable of handling up to 100,000 tonnes per year
- complex channel and in-vessel systems, which are capable of composting quantities in excess of 250,000 tonnes per year.

Logically the type of system chosen will depend upon the size of the community or institution, the amount of available feedstock to be composted and the capability of the operating authority to finance the operation at rates which compare well with other methods of organic waste treatment. Climate and special circumstances (*e.g.*, the need for in-vessel systems in areas where the storage and processing of organics attracts unwanted wildlife and vermin) will require more specialized system designs and collection methods, none of which pose insurmountable limitations for any Alberta community.

In terms of program performance, cost and compatibility it is expected that the average rural Alberta town with a population of 4500 (including the rural region immediately surrounding it) can generate up to 34,000 tonnes of organic waste through both municipal and agricultural sources (approximately 2,000 tonnes from the municipal stream and 32,000 tonnes from the agricultural stream). Depending upon the waste stream actually targeted for compost processing, communities of this size can use less complex

operations such as static piles or windrow systems, where capital costs can be from $10,000 to $100,000 and operational costs in the order of $25 - $45 per tonne are most applicable.

In larger centres or metropolitan regions where feedstock is generated at a rate of 250,000 tonnes per year or more, larger in-vessel systems are required. Processing costs can exceed $65 per tonne and capital costs can exceed $30 million. From an economic perspective, composting is sustainable in communities where landfill tipping fees are now in excess of $25 per tonne.

From a ***social perspective***, the sustainability of composting will improve with expanded awareness and education about the benefits of compost. Just as office paper collection programs have set the stage for a recycling ethic, home composting may well serve as a catalyst in developing grass roots ethics for composting.

From an ***environmental perspective***, composting can occur without major health and environmental risks provided that programs and systems are managed in accordance with guidelines and regulations.

From a ***physical perspective***, composting is sustainable anywhere in Alberta, in that the necessary feedstock exists at all levels and in all communities. Process technology is available for any level of operation and waste collection and transportation services are already in place or can be retrofitted at little or no cost. As well, beneficial applications for compost exist throughout the province.

From an ***economic perspective***, composting programs and process options must be tailored to suit local conditions. As the cost to landfill waste increases, so will the economic viability of composting. Municipalities must begin to position themselves for change by experimenting with low cost compost operations, regionalizing efforts in rural areas and encouraging source reduction through localized institutional, commerical and home composting programs.

This study is intended to provide a framework and a basis of knowledge to assess the sustainability of composting as a primary method of waste reduction in Alberta. It is hoped that the findings from this research will enable those wishing to compost, to identify and measure the viability of composting organic material from a variety of sources and within the context of existing or planned waste management systems.

The rationale behind the study rests with the need to seek sustainable options for waste minimization and material recovery. Albertans have come to the realization that waste doesn't just go away. It builds up, and has been doing so at a rate of over 500 kg per person every year, or about 1.5 kg per person per day in the average household; and that is just in weight. Put into bags, that represents two standard garbage bags every week -over one hundred bags each year, enough for an average family to fill a single car garage. In a town with a population of 2,500, that would fill two average-sized indoor ice arenas. When commercial and industrial sector garbage is added, the annual volumes double.

This study provides an assessment of numerous composting options in terms of their sustainability, or their ability to endure in the social, environmental, physical and economic context of the Province of Alberta.

From a social perspective, composting in any form must be accepted by the public as a desired alternative to conventional means of waste disposal. In this regard, its incorporation into any system must conform to socially accepted environmental ethics and accepted principles and laws of health and safety. There must be a willingness to accept changes in the way we now discard and dispose of organic waste.

From an environmental perspective, the process, technology and product must be seen as having less impact on the environment than conventional landfilling. If it can be seen to provide opportunities to reduce, re-use, recycle and/or recover renewable resources, and if it reduces the dependence upon non-renewable resources, then it can be viewed as having a positive effect towards a sustained environment.

To endure or be sustainable in a physical context, there must exist an ongoing supply of feedstock, the compostable organics, and the process of composting must, either through management, technology or both, operate at rates which ensure continuous "turn over" of incoming feedstock and end use of the product.

To be sustainable from an economic standpoint, composting programs must be shown to be either comparable to or less costly, in the long run, than other methods of waste reduction. Programs should provide potential opportunities for employment, and must perform on an ongoing basis without imposing incremental costs on the financial resources of an individual, a community, or a region.

The research and analysis presented throughout this document provide an attempt to measure the degree to which various composting options meet the above noted conditions for sustainability. The document is structured in a logical format which allows the user to focus upon the supply of composting feedstock, the issues associated with the overall concept, the various processes available for composting and the impacts of incorporating composting programs within various sized Alberta communities.

Much detailed analysis has gone into the development of the report and, although summaries are provided, the additional back-up information has been compiled into a separate document entitled "Sustainable Composting Options in the Province of Alberta: Technical Appendices".

1.1 Canada's Green Plan

Canada's Green Plan for a Healthy Environment, released in 1990, presents a framework of action for clean air, water and land. The plan is based upon the fact that our health and the environment in which we live are inseparably linked. A significant aspect of the plan is solid waste reduction, in fact the primary goal is to cut waste going to landfill by 50% by the year 2000.

To achieve this goal, the Canadian Council of Ministers of the Environment proposes that a harmonized strategy will be developed which ascribes to the 4Rs hierarchy. The focus of practical attainment of the goal will shift from province to province. While a general beneficial outcome of the process will be a change in the attitudes of our "throw away" society, the effects include a reduced dependence on landfills for disposal. This will, in turn, reduce the need to site new landfills in the face of increasing expense necessary to make them environmentally and socially acceptable.

1.2 Alberta Environment's Initiatives

Alberta Environmental Protection's Waste Minimization Branch has responded to Canada's Green Plan. The Branch has brought together three task forces to promote and develop safe and successful composting in the province: Guidelines and Standards, Public Awareness and Education, and Programs and Funding. This study is commissioned through the Programs and Funding Task Force.

The Department of Environmental Protection has supported a study on the feasibility of establishing a Centre for Composting Research and Development at Olds College and commissioned a number of Regional and Municipal Solid Waste Action Plans. The Waste Minimization Branch has assembled and will continue to update an extensive bibliography of composting literature, and consultative staff and planners are working with many Alberta municipalities and individual practitioners on an ongoing basis. The department has delivered financial support to municipalities conducting composting pilot projects in Alberta.

Other provincial departments and agencies, such as Economic Development and Tourism, have assisted Albertans with innovative programs aimed at the development of equipment for composting and numerous other related waste reduction initiatives.

1.3 Alberta's Urban and Rural Situation

Compost can be made on any scale, but always needs warmth and moisture to work effectively. Alberta's climate is characterized by the typical prairie conditions of a long cold winter and relatively dry air. Natural aerobic degradation takes a long time in these conditions. Not all the successes that have been demonstrated elsewhere will be replicable in Alberta. Moreover, only a few of our larger communities generate sufficient bulk of compostable materials to warrant the expense involved in construction and operation of the large mechanically accelerated composting systems that have been developed in Europe and the United States. Also the distances that separate many rural communities in Alberta make the cost of transportation an important consideration in the viability of centralized composting for a number of these isolated smaller communities.

However, as composting becomes increasingly well understood in Canada through, among other forms of information exchange, the systematic research of the department and the Composting Council of Canada, a diversity of approach is developing which may contain - in whole, in part, or in seed thought - solutions for our range of differing circumstances. Well thought out schemes can even receive a measure of start-up assistance from the programs of the Federal Government like Environmental Partners, and from private sources such as the Procter & Gamble Environmental Fund. The stage is clearly set for an investigation of the possibilities that may be applied to Alberta's case.

2.1 Purpose

The purpose of this study is to provide a report on the relative advantages and disadvantages of selected composting options that can be applied within Alberta and to identify opportunities or viable options for composting organic waste from a variety of generators within particular communities in the Province.

2.2 Objectives

1. To assess existing and potential feedstock availability for composting programs from the primary generators (*i.e.*, Residential and Industrial, Commercial and Institutional (ICI) operations).
2. To identify the most prevalent current and local issues associated with composting of residential and ICI organic matter in either centralized or backyard programs.
3. To evaluate the relative strengths and weaknesses of composting options for each of the residential and ICI sectors, in the context of existing or planned regional waste management systems, and to clearly express any benefits of composting options.
4. To determine the potential market for Alberta-produced compost.
5. To identify options for government action that may be necessary and sufficient to support composting programs in Alberta.

2.3 Study Scope

This study is limited to an investigation and analysis of composting options that are appropriate for rural and urban municipalities within Alberta. The options analysis have been selected from a review of programs and technology in North America and in some cases, Europe.

In all instances, the assessment of feedstock supply, in the form of source, quantity and quality is based upon averages taken from a series of actual waste audits and extended to typical community models. The composting issues, technologies and relative costs presented throughout are based upon secondary literature review.

2.4 Study Methodology

The study was conducted over the course of four months beginning in May of 1993 and culminating at the end of August 1993.

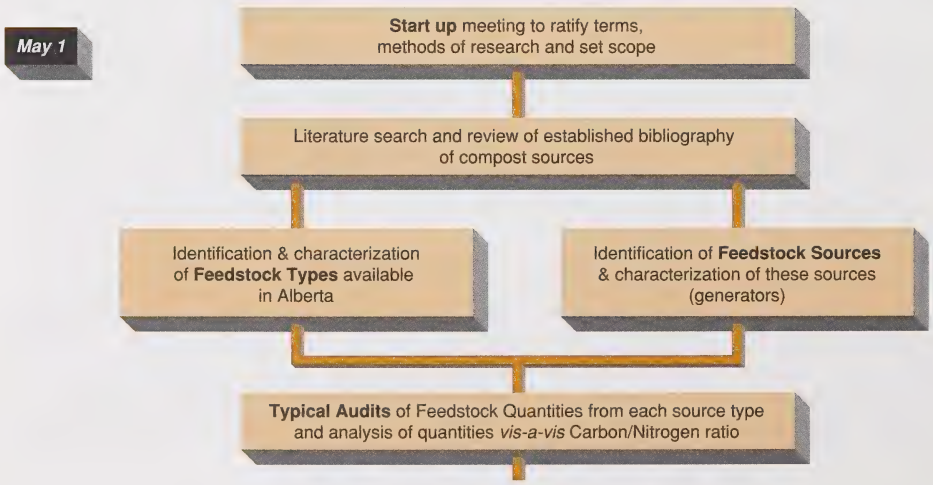
The methods of research and analysis were of a secondary nature, wherein a number of contemporary studies and reports from North America and other countries served as the basis for the identification of composting options and the issues of concern surrounding them. Primary research, although limited, was undertaken in the form of a focus group meeting with health officers and a comprehensive compost practitioner and stakeholder workshop held at Olds College in mid-July.

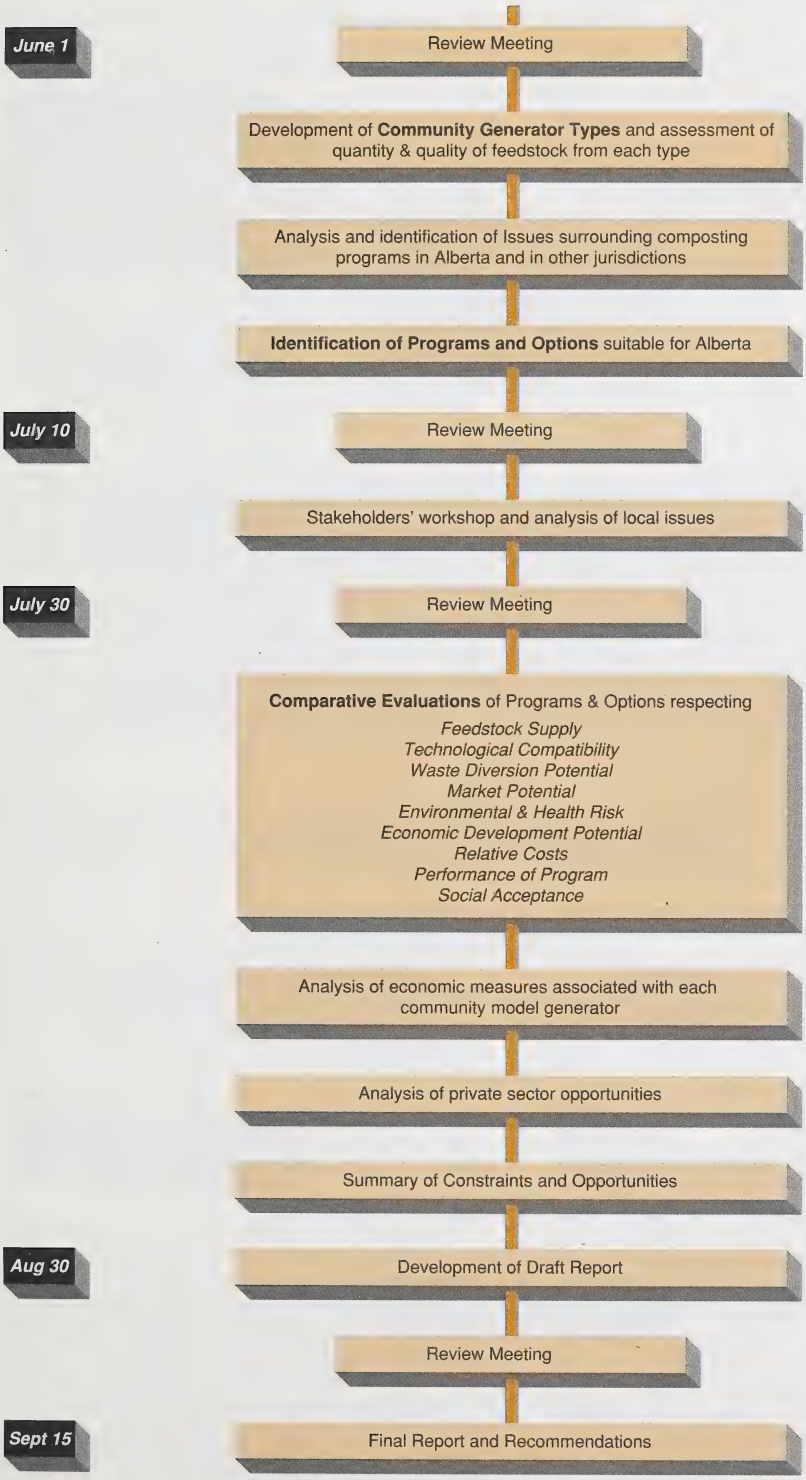
The consultant group collectively provided a significant amount of information from recent waste management audits taken from Alberta businesses and institutions, and expanded upon these audits through numerous telephone interviews.

Meetings between the consultant and the department initiating the study were held at three major junctures. These meetings served to confirm acceptance of data presented and to ratify the ongoing research approach.

The research and planning process utilized is presented in Figure 1.

Figure 1 - Study Process


May 1
Start up meeting to ratify terms, methods of research and set scope
Literature search and review of established bibliography of compost sources
Identification & characterization of Feedstock Types available in Alberta
Identification of Feedstock Sources & characterization of these sources (generators)
Typical Audits of Feedstock Quantities from each source type and analysis of quantities vis-a-vis Carbon/Nitrogen ratio


June 1
Review Meeting
Development of **Community Generator Types** and assessment of quantity & quality of feedstock from each type
Analysis and identification of Issues surrounding composting programs in Alberta and in other jurisdictions
Identification of Programs and Options suitable for Alberta
July 10
Review Meeting
Stakeholders' workshop and analysis of local issues
July 30
Review Meeting
Comparative Evaluations of Programs & Options respecting
Feedstock Supply
Technological Compatibility
Waste Diversion Potential
Market Potential
Environmental & Health Risk
Economic Development Potential
Relative Costs
Performance of Program
Social Acceptance
Analysis of economic measures associated with each community model generator
Analysis of private sector opportunities
Summary of Constraints and Opportunities
Aug 30
Development of Draft Report
Review Meeting
Sept 15
Final Report and Recommendations

The literature on composting contains a multitude of definitions of the process. Some are very narrow and others are broad enough to include what can be considered and more properly understood as digestion, an essentially different process occurring in nature to similar materials but in different circumstances. For the purpose of this study, the definition of composting has been extracted from the 1991-93 Edition of the World Health Organization handbook on Urban Solid Waste Management, an authoritative and universally accepted publication.

> *Composting is an aerobic biological decomposition process which ultimately degrades organic material to carbon dioxide, water and a stabilized residue, principally humic substances, called* ***COMPOST****. Substantial quantities of heat are produced in the initial part of the process, causing the temperature to rise. This, in turn, vaporizes off moisture, thereby reducing the weight and volume of the biomass by some 50% during the maturation process.*[1]

In the following discussion therefore, the use of the word *composting* includes only aerobic processes of biomass degradation, which occur naturally or in some managed system which accelerates the breakdown of the organic materials and formation of compost. When the process is applied to municipal solid wastes, a rough rule of thumb is that about 1/3 (by weight) is made into compost, 1/3 is lost by vaporization and 1/3 remains for disposal by other means.

3.1 The Process of Composting

The composting process (see Figure 2) is carried out by naturally occurring microorganisms which will spontaneously grow in any natural organic waste if the desirable moisture content and aerobic conditions exist. After a short initial phase of about one day required for colonization of the medium, microorganisms (bacteria, actinomycetes and fungi) rapidly invade the biomass, first attacking the more easily metabolized substances such as sugars, soluble proteins, starch and organic acids. During this stage, the oxygen consumption and CO_2 production by microbial metabolism is very rapid. To ensure sustained microbial metabolism, the oxygen level in the internal atmosphere should be maintained in the range of 15% - 20% O_2, with enough air admitted to keep the concentration of CO_2 at less than 10%.

The high metabolic activity generates heat, which causes the temperature of the composting biomass to rise above 60°C. The resulting high temperatures have a strong selective effect on *thermophilic bacteria*, bacteria which thrive at these high temperatures. They promote helpful spore growth and inhibit the growth of a wide range of other microorganisms. Other bacteria, actinomycetes and fungi are strongly inhibited. Since only a few species of such bacteria show metabolic activity above 70°C, the temperature should be kept below this critical limit.

When the readily assimilated contents of the biomass have been metabolized, the rate of microbial activity decreases and the temperature starts to drop. When it reaches about 55°C, the other microbial groups become active again. Towards the end of the process, at an advanced stage of stabilization, the fungi and actinomycetes have their highest activity rate, while bacterial activity begins to decline. Several species of mesophilic and thermophilic organisms actively degrade large polymers, such as cellulose and lignin.

The decomposition of cellulose is particularly intense during this final stage, predominantly through the activity of eumycetes. The degradation of lignin is restricted to a limited microbial group, namely the higher fungi, basidiomycetes. Decreases in temperature and moisture content towards the later stages of composting are better suited to the activity of the fungi and actinomycetes which are crucial to the humification of the organic matter.

Not all biological materials decompose fully during the composting process. Lignin, the hard content of wood, is decomposed only slowly and keratinous materials (horn, hair, etc.) can be a problem. Cellulose is relatively resistant to biodegradation when associated with lignin as lignocellulose, which is found, for example, in straw and wood. The use of preservatives/additives (such as those used in the production of good quality or waxed paper) can render these materials even more resistant to biodegradation. Under the conditions found in unaided natural decomposition, all of the materials described are ultimately biodegradable, but not in the several weeks typical of a simple, non-mechanical composting process.[2]

3.1.1 Indicators

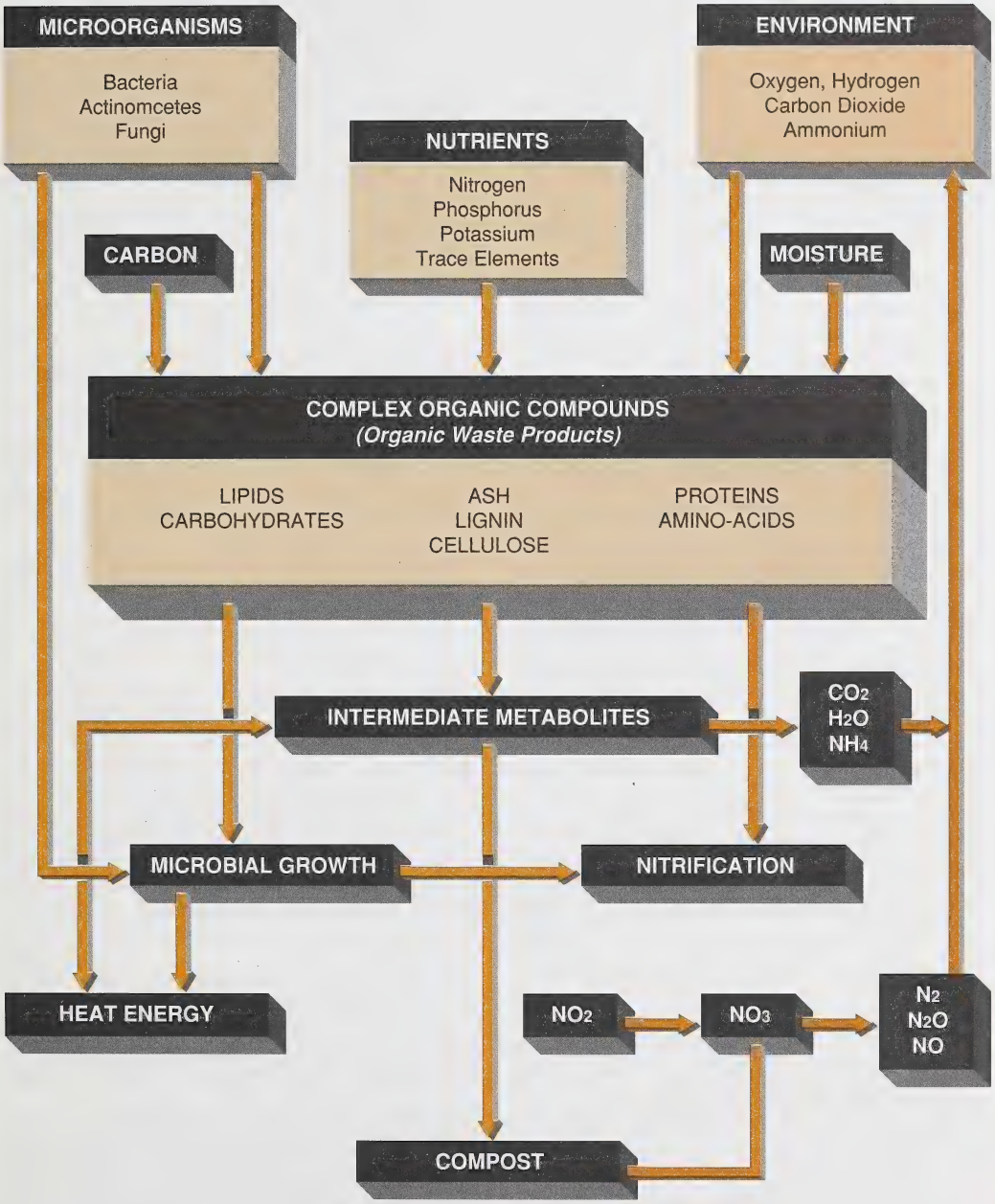
Since composting is an exclusively biological process, all those factors which influence microbial metabolisms affect the process directly or indirectly.

1. **Operating temperature**

   Microbial activities during composting are greatest in the 30° - 55°C temperature range and process temperatures above 60°C are likely to reduce activity. In addition, some organics are not directly broken down by single organisms but are degraded by the "co-metabolism" of a group of different types of microorganisms working together. Therefore, maximizing microbial diversity in composting systems may allow a much wider range of compounds to be broken down successfully by co-metabolism during composting.

   The self-induced temperature increase characteristic of composting is at first favourable to heat generation and other visible signs of microbial activity but, if some of this heat is not removed, temperature generally becomes unfavourably high, suppressing the biological generation of heat (negative feedback). Aeration may be used to prevent temperature-sensitive reduction of microbial activity, based on observations that the microbial activity is inhibited at temperatures above 60°C, and that water evaporation is the main pathway of heat loss during composting under forced aeration.

Figure 2 - The Basic Composting Process



Source: In-vessel Composting Systems (A Brief Comparison), Jack Pos (Jack Pos & Associates Ltd. Guelph, ON). Proceedings 14th Canadian Waste Management Conference, Regina, SK, Oct. 7 - 9, 1992, Page 459.

2. **Moisture**

Moisture content is an important factor in composting. Water is both required for and produced by microbial activity. If the moisture content of the biomass falls below 20%, decomposition ceases. If it exceeds 70%, water begins to fill the interstices between the particles of the biomass, reducing its access to interstitial oxygen. This will cause a rapid fall in temperature and may also result in anaerobic conditions. A water content of 40% - 50% should be maintained during the earlier stages of the process in order to compensate for water loss through evaporation, until the final fall in temperature signals a change in the process and significant drying becomes beneficial.

The removal of water during composting is a major objective because a dryish residue is more easily screened, stored, transported and disposed of. In large scale composting systems the main avenue of heat removal is ventilation by a blower, resulting in the removal of water via vaporization. Simpler systems rely on biological activity alone to remove moisture. Provided that temperature feedback is used to control ventilation, water removal and decomposition are linked via heat generation and vaporization.[3]

3. **Oxygen**

Oxygen is usually supplied as air, which reaches the organisms by diffusion. If the moisture content is too high or if the composting mass is compressed, oxygen may be used up faster than it can enter the bulk of the composting mass and anaerobic organisms will start to grow. Anaerobic decomposition, which is really a form of *digestion*, will lead eventually to a stabilized final product, but the process is much slower and objectionable odours are produced. Furthermore, the slower anaerobic process does not produce enough heat to disinfect the product or to kill weed seeds and the resulting humus is less well tolerated by plants.

Ventilation plays other crucial roles in addition to removing heat and water vapour. These are to supply oxygen for aerobic respiration and to remove the resultant carbon dioxide. The amount of air needed to remove heat is always more than that needed to supply oxygen for the microbial process above. The optimum level lies between 15% and 20% of the internal atmosphere, a level maintained in mechanical composting processes by temperature feedback control. Aerobic composting is inhibited when oxygen is less than 10% by volume of the atmosphere within the biomass.

4. **Carbon:Nitrogen Ratio**

Bacteria use carbon as an energy source and nitrogen for cell building. The process of aerobic decomposition involves the reduction of the relative proportion of these elements, known as the *C:N* ratio, from an original level which may range from 20:1 to as high as 70:1 to a point where the available carbon has been consumed and activity ceases. The final *C:N* ratio of a stable compost is usually between 15:1 and 25:1.

The initial *C:N* ratio is a deciding factor in the speed at which decomposition takes place. The ideal initial ratio is between 25:1 and 35:1. Low *C:N* ratios may result in excessive nitrogen losses with ammonia being driven off, especially at high *pH* and temperature values. If the initial *C:N* ratio is greater than 35:1 the microorganisms must go through many life cycles, oxidizing off the excess carbon as carbon dioxide (CO_2) until a more convenient *C:N* ratio for the metabolism is reached. The time required for decomposition increases considerably. The organic fraction of solid refuse generally has a *C:N* ratio in the range 25:1 to 50:1, while sludges and manures may be much stronger in nitrogen content.

5. **Acidity or pH**

As in the case of temperature, the pH of the compost varies with time during the composting process and may indicate the extent of decomposition within the compost mass. During the initial two to four days of composting, the pH may drop from near neutrality (a pH of 7.0) to about 5.0 as organic acids are formed. Then it will begin to rise to about 8.5 for the remainder of the aerobic process as the organic acids are consumed in the thermophilic phase. If the process is allowed to become anaerobic, the pH will drop to about 4.5 and valuable nitrogen is then lost as ammonia (NH3).

3.1.2 Completion

The process of composting can be considered as completed only when the product is biologically stable, is not phytotoxic and is hygienically safe.

An important facet of the composting process is the determination of the point at which digestion of the solid waste has been completed. In general, satisfactory stabilization is attained when the compost has the characteristics of humus, has no unpleasant odour, high temperatures are not maintained even though aerobic conditions and desirable moisture content exist, and the carbon to nitrogen ratio is such that the humus can be applied directly to the soil.

Tests for the properties of finished compost are important, although the extent of testing required depends on the agricultural use intended. Compost derives its value from both its organic content and its gentle fertilizing capability, which should be measured for each batch and recorded along with the moisture content.

A practical measure of safety in relation to growing plants, for example the mustard seedling test[4] or the widely used watercress seedling test[5], may be useful. There are other plant growth tests but these are generally used more to demonstrate the usefulness of compost than as controls on final quality.[6]

Analyses for fertilizer elements and toxic heavy metals may be required for some applications. The Province of Alberta has yet to determine its criteria for acceptability of

compost for use in a variety of possible situations, and therefore for the purpose of this study, the present recognition of the standards required by the Environmental Choice program of Environment Canada are proposed. It should be noted that these standards reflect compost made ***without*** the inclusion of sewage sludge in the biomass. Limiting values of the heavy metals content in compost using sewage sludge recognized by the Agriculture Canada[7] are listed at (f) alongside for comparison, and will presumably continue to be recognized as acceptable until some other standard is adopted.

To be authorized to carry the EcoLogo the compost must:

(a) have been uniformly exposed to temperatures in excess of 55°C for 3 consecutive days,

(b) have a *pH* range between 5.0 and 8.0,

(c) have a minimum of 30% organic matter content (of dry weight),

(d) have maximum of 50% water,

(e) have a sodium adsorption ratio less than 5,

(f) not exceed the following amounts of heavy metals (in mg/kg dry weight):

			AgCan Limit
Arsenic (As)	-	13.0	(75)
Cadmium (Cd)	-	2.6	(20)
Chromium (Cr)	-	210.0	(n/a)
Cobalt (Co)	-	26.0	(150)
Copper (Cu)	-	128.0	(n/a)
Lead (Pb)	-	83.0	(500)
Mercury (Hg)	-	0.83	(5)
Molybdenum (Mo)	-	7.0	(20)
Nickel (Ni)	-	32.0	(180)
Selenium (Se)	-	2.6	(14)
Zinc (Zn)	-	315.0	(1850)

(g) have a maximum particle size of 13mm,

(h) not contain plastic in excess of 0.4% by dry weight and any combination of glass, rubber and/or metal in excess of 1% by dry weight if such particles have a dimension in excess of 2mm,

(i) not contain PCBs in excess of 1 ppm,

(j) have a maximum electrical conductivity of 3 ms/cm, and

(k) be derived from source-separated municipal waste.

It is evident that standards proposed for compost made from source-separated wastes are over-stringent for composts which utilize the nutrients contained in waste water sludges and the water content of these sludges as process moisture. No decision has yet been made as to limits on the applicability of such composts in Alberta, where spreading of uncomposted sewage sludges on farmland is widely practiced (*e.g.*, Olds, Edmonton, St Paul). It is noteworthy that the State of Minnesota, where composting is well established as a waste reduction technique, subjects application of composts containing sludge to permitting procedures regardless of their heavy metal content, and designates them Class II Compost regardless of other parameters of acceptance such as particle size, maturity and so forth, subject to controlled application by permit.

3.2 Suitable Feedstock for Composting

Within the guidelines set for this study[8] the discussion is limited to those organic materials which arise in significant quantities in the natural wastes of biological activity within the Province, and those which are byproducts of industrial or commercial processes. In practice, compostable materials will almost always be mixed with a certain amount of non-compostable organic or inorganic materials, some of which actually assist the process by maintaining air passages in the composting biomass* and some of which could be harmful if contained in the final compost.

Virtually all naturally occurring organic materials are compostable and many which are the byproducts of industrial activity, although some will require greater or less degrees of pre-preparation to make them suitable for decomposition in a realistic time-frame. *Organic materials* are composed primarily of carbon, hydrogen and oxygen, originally of animal or plant origin. Yard wastes and animal manures may be seen as typifying this natural category, sewage sludge as typical of an industrial process byproduct. Plastics and textiles on the other hand, while made up of organic materials, do not compost.

It is evident that rural and urban sources of compostable materials have considerable overlap but are nonetheless distinct in many details. Farms, for instance, generate quantities of very readily composted manures and soiled bedding - Olds College Farm is an example, and Bowden Institution is another - which are not readily available in towns except at stockyards, race tracks and similar concentrations of livestock. Chicken and pig manures differ in their moisture content and *C:N* ratio from beef cattle, and beef cattle differ from dairy cattle or horses. On the other hand, cities generate quantities of readily available yard waste, vegetable wastes from large urban food processing operations and supermarkets, cooked food wastes from hotels and restaurants and other nitrogen-rich organic wastes from breweries. They also tend to accumulate a large surplus of paper of types that do not presently have a ready recycling market. This paper can be made into a substitute animal bedding for the farms or stockyards and thus find an indirect route into the compost option, or direct as a carbon balance and dry complement of nitrogen rich water-treatment sludges. These examples, though far from exhaustive, will serve to illustrate the diversity of compost sources in different parts of the province, and of ways that they can even be made interactive for their mutual benefit.

3.2.1 What Can be Composted?

It should be recognized that since not all refuse is compostable, an additional treatment system (incineration or landfill) must be available to treat and dispose of

* The Leds University system developed in Britain depends on this, as did the HVA system that was successfully operated in Holland for many years.

composting rejects, which represent a significant proportion of waste entering any composting process. Depending largely on the composition of the waste stream to be composted, which will be affected by how much has already been withdrawn for recycling, by the climate and other variables, about 1/2 to 2/3 of the incoming waste can be composted. A considerable amount of moisture will have been added in the process, so 1 tonne of average urban waste can yield 350 - 500 kg of compost. Some of the organic material is converted into water vapour, some becomes CO_2 and both are lost to the atmosphere. The remainder of the incoming waste, all that could not be composted, or recycled must be disposed of. This may well amount to 350 kg in every tonne, and in Alberta it is generally landfilled.

In practical terms, since the balance between available carbon and available nitrogen (the *C:N* ratio) is so crucial to successful composting, it is helpful to form simple broad categories of the most commonly occurring compostable materials according to their predominant contribution to this essential balance. Typical values of the *C:N* ratio of commonly occurring compostable materials are shown in the following Table 3.1, adapted from the Compost Facility Operating Guide for Municipal Solid Wastes issued by the Solid Waste Composting Council, of Alexandria, Virginia. These values, and their usefulness as a guide to the successful combination of materials for optimum results of the composting process, have stood the test of time and are as useful today as they ever were. Composters blend materials with high and low *C:N* ratios to form a mix with a combined ratio near the ideal value of 35:1.

Table 3.1

FEEDSTOCK PREPARATION / C:N RATIO CONTROL

C:N RATIO OF VARIOUS WASTES

Material	*C:N Ratio*
Urine	0.8
Blood	3.0
Cow manure	18
Poultry manure	15
Activated sludge	6
Grass clippings	12-15
Non legume vegetable wastes	11-12
Dry leaves	40
Potato tops	25
Straw, wheat	128-150
Paper and wood	200
Sawdust	200-500

Source: Golueke, CG: Biological Reclamation of Solid Waste, Emmaus, PA: Rodale Press, 1978

3.2.2 Availability of Feedstock

For the purpose of this study it will also be helpful to categorize the various compostable materials presently going to waste (or being disposed of in an environmentally wasteful way) as of Primary or Secondary availability in any given situation. Farm manures, for instance, are a primary source in many rural communities, where the prevalent practice of manure-spreading loses about two thirds of their available nitrogen and releases methane gas, which contributes to the ozone layer depletion. Except where there is a major stockyard or similar concentration of livestock, they will be a secondary source in many towns. By contrast most cities generate a great surplus of mixed paper waste that is not yet within the capability of most recyclers to recover profitably, some of which can be composted as a balance to grass clippings and vegetable wastes which are rich in nitrogen. In rural communities, which are relatively scattered, there is less ability to amass large quantities of paper, and so it figures less as a primary item for waste diversion.

Because composting is also envisaged as a means of diverting materials from landfilling, the contribution of each type of waste to this form of ultimate disposal using current technology is also a consideration in categorizing it as primary or secondary.

Primary is therefore defined by:
- prevalence in quantity available for composting
- large contributor to landfill as currently disposed of
- fewer alternatives for recycling, hard to recycle or not competing with other forms of recycle activity
- higher content of C or N, as required for balance
- more rapid success for breakdown under ideal conditions
- fewer known constraints for contamination or health risk
- less need for extensive pre-treatment

Secondary is defined by:
- less prevalent in quantity in a given community
- less volume at landfill, small diversion potential
- considered easily recyclable through traditional channels
- low or medium C or N content
- slower breakdown in composting process
- known constraint on account of contamination or health risk, odour, etc.
- requires more pre-treatment or more care in handling

3.2.3 Characteristics of Feedstock

A categorization of typical organic materials which are known to be suitable as feedstock for a variety of composting processes can be based principally on the six parameters:

Nitrogen Rich / Carbon Rich
Solid Waste / Liquid Waste
Primary Source / Secondary Source

Table 3.2, which follows, exhibits the types of feedstock which can be found within Alberta along with their respective characteristics as described by the parameters above.

Table 3.2 - Organic Compostable Wastes Feedstock Types

FEEDSTOCK CHARACTERISTICS	SOLID WASTE	LIQUID WASTE	CARBON RICH	NITROGEN RICH	RISK RIDDEN	RISK FREE	AVAILABLE NATURALLY	BYPRODUCT	EASY	HARD	PRIMARY SOURCE	SECONDARY SOURCE
SOURCE TYPE **SYMBOL**	**S**	**L**	**C**	**N**	**R**	**F**	**A**	**B**	**E**	**H**	**1**	**2**
PLANT WASTE												
"Green" Waste												
discarded crops	X		X			X	X			X		X
vegetable & plant leaves	X			X		X	X			X	X	
weeds / seaweed	X			X		X	X			X		X
grass clippings	X			X	X		X			X	X	
"Brown" Waste												
straw / hay / corn husks	X		X		X		X		X		X	
milling husks / peanut hulls	X		X			X		X	X		X	
spent hops / brewery wastes	X			X		X		X	X			X
spent fruit pressings	X		X			X		X		X	X	
WOOD PRODUCT WASTE												
Wood Waste												
bark / branches / pine needles	X		X			X	X			X	X	
sawdust & woodchips	X		X		X			X		X	X	
wood ash	X		X		X			X		X		X
Paper Waste												
newsprint	X		X			X		X	X			X
wrappers	X		X			X		X		X	X	
paper towels / napkins	X		X		X			X		X	X	
junk mail / flyers / envelopes	X		X		X			X		X	X	
Cardboard Waste												
container boxes	X		X		X			X	X			X
cereal & packaging boxes	X		X			X		X		X	X	
ANIMAL WASTE												
Body Parts												
morts & body parts	X		X		X		X			X	X	
blood, bone & viscera	X			X	X			X	X			X
hair, feathers / skin, scales	X			X		X		X		X	X	
Manures												
dry manure / litter	X			X		X	X		X		X	
manure / faecal slurries		X		X	X		X		X		X	
paunch slurries		X		X	X			X		X	X	
rendering residues / bone meal	X			X		X		X	X			X
FOOD WASTE												
Raw Food												
vegetable trimmings / scraps	X			X		X		X		X	X	
spoiled fruit / peel / scraps	X			X		X		X		X	X	
meat / poultry / fish scraps	X		X		X			X		X		X
Cooked Food												
cooked meats	X		X			X		X		X	X	
baked goods	X		X			X		X		X	X	
Food Containers												
soiled paper / cardboard	X		X			X		X		X	X	
LIQUID WASTE												
Commercial												
cheese whey		X		X		X		X		X	X	
spoiled beverages		X	X		X			X		X	X	
Industrial												
sewage sludges		X		X	X			X	X		X	
lagoon sludges		X		X	X			X		X	X	
septage		X		X	X			X		X		X

4.1 The Foundation of Feedstock Generation

Since the basis of all living matter is organic, all natural life and activity generates organic wastes, which are mostly compostable. Plants (and other forms of vegetation) and animals produce such compostable materials in their natural life and decay process. Man so organizes nature as to concentrate many of these natural generators - as, for instance, in intensive livestock culture - and to produce others as byproducts of industrial and commercial activity, such as paper making sludges and spent brewery mash. A broad characterization of the three primary generators is outlined below:

Plants and other vegetation create relatively carbon-rich materials in the process of annual decay, through leaves falling to the ground in a "brown" lifeless condition, and stems (as well as larger branches and tree-trunks) rotting away. They are also the source of wet, nitrogen-rich grass, leaves, stems and so on if harvested in the "green" growing stage, as lawn clippings and other yard waste are in spring and summer.

The interaction of people with plants changes long-established natural balances. The waste materials from intensive cultivation can become more abundant than nature can cope with on its own. Bark and wood chips from lumber processing and mounds of spent, pressed berries left over from fruit processing, for instance, have to be disposed of in some practical way. Burning the hog fuel often provides mills with an additional source of power. Landfilling the press-cake wastes eliminates its useful potential as a low-grade fertilizer.

Animals create comparatively nitrogen-rich materials as faeces and urine, which degrade naturally on the ground. Much of the nitrogen is lost to the atmosphere as ammonia (NH_3) and, as a result of more-or-less anaerobic decomposition, as methane (CH_4). Birds and fish, of course, do much the same, but the wastes are often less visible, deposited in nests or in water. The body wastes of smaller life forms, insects and worms for instance, tend to be incorporated more directly into the soil in a generally beneficial way.

When any form of animal life is intensely cultivated, as in chicken broiler houses, hog barns or stock fattening pens, the accumulation of wastes mixed with soiled bedding can become a problem requiring careful management to avoid both the degradation of the environment and the loss of much value from this resource. Fish farms face a similar management problem, to which is added the need to dispose of anything that has died ("morts") and the visceral remains of processing. All of these animal wastes can be successfully composted.

People create an amazing variety of wastes that can become feedstock for composting processes, both in direct and indirect ways. We are responsible for the accumulation of animal and plant wastes at farms, stockyards and vegetable processing facilities. We produce kitchen wastes and yard wastes, paper that can become animal bedding and so find its way into the compost, yard waste from our gardens that, in summer, is often half the waste hauled away by municipal and other refuse collectors.

Indirectly, our body wastes become the sludge from sewage treatment works. Our commerce and industries all produce waste streams and many of them are readily compostable, such as out-dated baked goods from delicatessens and faded cabbage leaves from supermarket shelves. Sometimes, because of the chemistry of co-metabolism referred to at 3.1.1 above, individual wastes which are difficult to dispose of on their own compost well when mixed together. Agriculture Canada has explored several such innovative composting techniques, as for instance fish wastes rich in nitrogen with sawdust; a largely carbon-rich waste product from so much Canadian industry.[9] As well, Prince George's County in Maryland has successfully composted broken pallets piled up at its landfill with grass clippings that would have gone there[10].

Living communities are made up of all three groups of generators and all three contribute quantities of compostable waste or feedstock at varying rates. The rate at which compostable wastes are generated and their availability as feedstock for a composting program in any community have to be examined. The social structure and the productive activity of the community will have a bearing on the way the primary generators contribute wastes within their collective environment and so produce the feedstock in sufficient mass to make composting worth while.

Table 4.1 identifies these sources of feedstock. Not all sources will be equally productive in every community. The relative numbers of each generator within communities will vary according to community size and function. To reflect the possible mix of sources within recognizably different communities, generating sources are categorized by residential, industrial, commercial and institutional origin.

4.2 Community Generator Models

In Alberta, the practice of composting at the municipal level is in an experimental stage. A number of communities like the City of Fort Saskatchewan and larger cities like Edmonton, have developed programs to collect and compost residential yard wastes. The development of these pilot programs are ongoing and are monitored on a continual

Table 4.1 - Feedstock Generators

Generator Category	Generator Sub-Category
RESIDENTIAL	• Single Family • Multi Family (town housing, duplexes, etc.) • Apartments / Nursing Homes / Seniors Residences
COMMERCIAL	• Restaurants • Hotels / Motels • Grocery / Supermarkets • Butchers / Meat Producers • Bakeries • Banks / Financial Institutions • Professional Offices • Gas Stations • Food Wholesalers • Printing / Publishing • Services Retail • Services Wholesale • Greenhouses / Market Gardens • Horticultural / Landscape Services • Transportation
INDUSTRIAL	**Agricultural:** • Mixed Farms • Dairy Farms / Creameries • Feedlots • Poultry Farms • Food Processing Plants • Grain Elevators / Mills
	Forest: • Logging Operations / Mills • Wood Product Industries
	Petro Chemical: • Refineries / Gas Plants • Seasonal Camps
	Leisure Tourism: • Sports & Leisure Facilities • Fairgrounds • Major Resorts • Golf Courses • Campgrounds / Day Use • Special Attractions / Zoos
INSTITUTIONAL	• **Government Offices** • Military Bases • Prisons • Hospitals • Educational Institutions • Churches • Municipal Waste Handling Facilities - Solid • Municipal Waste Handling Facilities - Liquid

basis to determine their viability and sustainability. They are however considered as small scale projects and at the levels in which they operate do not impact significantly in reducing landfill waste. At the household level, some communities over the past three years have introduced backyard composting programs and although the verdict is not out on their sustainability, it is expected that a small portion of residents are involved and will continue the practice.

Composting can occur at various levels provided that sufficient quantities of feedstock are available, the right conditions prevail, and if proper procedure is followed. These variables occur at the lower end of the spectrum as in household or backyard composting, up to higher order compost operations such as those servicing cities like Seattle, Washington.

Much research is yet to be done and more experimentation, however there is evidence that an increasing number of communities and individuals are prepared to consider composting as an option for waste reduction and recovery. The methods of composting and the degree to which composting initiatives achieve sustainability will depend upon a number of community factors including:

Population:
wherein the relative number of people, or "feedstock producers" will have a direct relationship to the amount of feedstock available and the level of tax base for revenue generation.

Land Use Region:
wherein the surrounding land use will have a direct impact upon the amount and types of feedstock available.

Industry Mix:
wherein the types of industries within communities will have impact upon the amount and types of feedstock available.

Distance and Transportation:
in the case of communities which must rely upon more distant sources for the attainment of, for example, nitrogen rich manure for a successful compost operation.

Predisposition:
or the overall attitudes and ultimate propensity of community residents to engage in recycling and/or composting programs.

Climate:
wherein temperature and rainfall will impact upon outdoor composting operations.

Alberta is comprised of 16 cities, 108 towns and 172 villages (including summer villages). Cities are those communities which have populations in excess of 10,000 people. Towns can range in populations between 1,000 and 10,000 and Villages represent communities of 1,000 or less.

The overall population of Alberta in May of 1991 was estimated at 2,358,000 (Alberta Municipal Affairs population list). If the current industry standard of 1 tonne per person per year is used as a relative guideline for solid waste generation, the population of Alberta generated some 2.3 million tonnes of solid waste of which an estimated 70% or close to 1.6 million tonnes was compostable.

These gross figures can be misleading, since municipal solid waste or measured landfill waste is but one source of compost feedstock. Other major industries which can contribute feedstock include agriculture and forestry where, for example, close to 48 million tonnes of manure and waste wood product are generated in the province each year (see Table 4.9).

In recognition of the fact that each community in the province will have its own unique possibilities to generate organic wastes that can become feedstock for a composting operation, the research for this study specified seven types of communities to represent the major variants. These model communities differ by size, by composition of municipal elements and by the major industry of the land surrounding the urban nucleus. Taken together, these parameters provide a basis of measurement for the quantity and quality of feedstock that is likely to be available, which can then be matched up against a pre-determined number of composting program options.

The community models chosen for the study are presented on the following pages. The generators depicted within each model have been developed by first reviewing community profile publications that have been provided by Alberta Municipal Affairs and taking averages of at least five profiles within each community model category. To verify the existence and quantity of generators present, spot checks were conducted from local telephone directories. All population figures and housing types were provided through 1991 Alberta Municipal Affairs census data. These models have been developed for analytic purposes and, although they are based upon sound averaging, inconsistencies may exist. For example, the City of Edmonton is a government centre and, as such, will have a far greater percentage of government buildings per capita than other centres. For those wishing to prepare organic waste audits within their own community, these prototypical models may serve as a valuable guide.

MODEL #1 - VILLAGE / SMALL COMMUNITY

General Description:

This model has been chosen to depict the average sized Alberta Village, of which there are 172 in the province. It can be expected that these communities may be found in all geographic regions and therefore they may be influenced by a surrounding agriculture, forestry or resource extraction industry. It is assumed that these communities for the most part will be members of a regional waste management system and experience more barriers to reduce and recycle than in larger more concentrated centers where waste removal costs are more critical and where recycling alternatives are more readily available. It is also likely that community based composting programs have either not been considered or are in a primitive stage of development. The Small Community model can also be used to characterize Metis settlements, Indian reserves, colonies and, in some cases, small institutional enclaves like small colleges and industry camps.

Model #1 - Village / Small Community Profile

POPULATION:	400 (45,107÷ 122 villages = 370) Quantity	
RESIDENTIAL:	Number of Dwellings (Average 144)	144
	• Single family	125
	• Mobile home	15
	• Multiple / Apartments - 4 units (90 residents)	4
COMMERCIAL:	Restaurants — 1 per	1
	Hotels / Motels	0
	Groceries Retail	1
	Butchers / Meat producers	0
	Bakeries	0
	Banks	1
	Professional Offices	4
	Gas Stations / Convenience	1
	Retail Services	4
	Wholesale Services	0
	Greenhouse / Market Garden	0
Transportation:	Depots at local outlets	
INDUSTRIAL:	Insignificant contributor	
Forest:	Depends upon location	
Petro Chemical:	Depends upon location	
Leisure Tourism:	Insignificant contributor	
INSTITUTIONAL:	Office buildings (25 employees)	1
	Schools	1
	Churches	1

Examples of Alberta Villages include:
Sangudo (population 401)
Wanham (population 283)
Myrnam (population 383)
Bawlf (population 375)

MODEL #2 - TOWN AND NON-FARM COMMUNITY

General Description:

Towns in Alberta, of which there are 108, can range in size from 1000 population to 10,000 population. The majority are located within agricultural areas. Some, however, are located within the forested areas of the province and support an industry base comprised of forestry, oil and natural gas.

The non-farm designation has been used to distinguish this model from the Town & Farm model, since the accompanying land uses generate a different type of feedstock than that found in farm regions. A number of non-farm towns are located within the foothills and the northern regions of the province where colder temperatures will affect outside compost operations.

Because towns support larger populations than villages, they are likely to have waste management systems in place and are likely better equipped to entertain composting programs. Composting initiatives will vary according to the knowledge of those who are given the responsibility of operating waste management programs.

This town model can also be used as a basis of measurement for a larger institution such as a prison, college or university, where concentrated populations reside on a daily basis.

Model #2 - Town (Non-Farm) Profile

POPULATION:	3000 (329,654÷108 towns)	
RESIDENTIAL:	Number of Dwellings (Average 1000)	1000
	• Single family	800
	• Mobile home	100
	• Multiple units	100
COMMERCIAL:	Restaurants - (1 per 500)	6
	Hotels / Motels - (1 per 2000)	2
	Groceries Retail - (1 per 2600)	1
	Butchers / Meat producers - (1 per 3000)	1
	Bakeries - (1 per 3750)	1
	Banks - (1 per 1300)	2
	Professional Offices - (1 per 150)	20
	Gas Stations / Convenience - (1 per 1100)	3
	Retail Services - (1 per 100)	30
	Wholesale Services - (1 per 600)	5
	Greenhouse / Market Garden - (farmers market)	1
	Landscape Services - (1 per 2700)	1
Transportation:	Bus Depot	1
	Train Station	1
INDUSTRIAL:	Contingent upon size and location	
Agricultural:	Insignificant	
Forest:	Logging operations / mills - typically 1 in region if forest related	
Petro Chemical:	Refineries / gasplant	
	Seasonal Camps - typically 1 in region if petrochemical related	
Leisure Tourism:	Major Sports & Leisure Facilities	2
	Fairgrounds (per town)	1
	Campgrounds (per town)	1
INSTITUTIONAL:	Government buildings (based upon average of 6.51 population in Government & 100 people per building)	2
	Hospitals (60 bed based upon 1 bed/50 population)	1
	Educational (based upon 1 per 500)	6
	Churches (based upon 1 per 1100)	3
	Municipal Waste Handling Facilities (per town)	1

Examples of this model:
Grande Cache (population 3600 - assoc. coal & mill operation)
Swan Hills (population 2412 - assoc. mill operations & petrochemical)
Whitecourt (population 6922 - assoc. mill operations & petrochemical)
Fox Creek (population 2259 - assoc. mill operations & petrochemical)
Crowsnest Pass (population 6912 - assoc. mill operations)

MODEL #3 - TOWN AND FARM COMMUNITY

General Description:

The majority of the 108 Alberta towns, which range in size from 1,000 to 10,000 population are located within agricultural regions. They possess distinct advantages over non-farm communities in that feedstock generation capability is greatly improved by virtue of domestic livestock, grain crops and associated farming operations. Also significant is the fact that agricultural activity has in many cases created a more comprehensive infrastructure by which commodities can be transported. Farm communities are more likely to have a history and understanding of farm based composting techniques (like manure compost) since land based operations provide a ready use for compost as an agricultural soil additive.

These communities have larger populations than villages and, as a result, are likely to have waste management systems in place and better equipped to engage in composting programs. Composting initiatives will vary according to the knowledge of local waste management personnel.

This model can also be used as a basis of measurement for larger institutions such as prisons, colleges and universities, where populations reside on a daily basis and where the surrounding agricultural activity is present. The town of Olds and Olds College are good examples of this model.

Model #3 - Town and Farm Community Profile

POPULATION:	4500 (based upon average town population of 3000 and rural trading area which is 1/2 town population)	
RESIDENTIAL:	Number of Dwellings	
	• In Town single family	1686
	• Rural farms (— 3.3 per household)	454
	• In Town mobile home	109
	• Multiple units / apartments	123
COMMERCIAL:	Restaurants / Food outlets	6
	Hotels / Motels	1.5
	Groceries Retail- (1 per 2600)	1
	Butchers / Meat producers (1 per 3000)	1
	Bakeries (1 per 3750)	1
	Banks - (1 per 1300)	2
	Professional Offices (1 per 150)	20
	Gas Stations / Convenience (1 per 1100)	3
	Retail Services (1 per 100)	30
	Wholesale Services (1 per 600)	5
	Greenhouse / Market Garden (farmers market)	1
	Landscape Services (1 per 2700)	1
Transportation:	Bus Depot	1
	Train Station	*1*
INDUSTRIAL:	Contingent upon size and location	
Agricultural:	(comparatives from Alberta Agriculture Market Analysis May '93) Mixed Farms (depending upon location 7% of farms)	32
	Dairy Farms/Creameries (location 4% of farms)	18
	Feedlots / Cattle & Pigs (location 37% of farms)	154
	Poultry (location 2% of farms)	9
	Grain (location 50% of farms)	227
	Grain Elevators / Mills (per community)	1
Leisure Tourism:	Major Sports & Leisure Facilities	2
	Fairgrounds	1
	Campgrounds (per town)	1
INSTITUTIONAL:	Educational	6
	Churches	4
	Municipal Waste Handling Facility	1

Examples include:
Calmar
Tofield
Sundre
Cochrane

MODEL #4 - SMALL CITY

General Description:

There are currently sixteen incorporated cities within Alberta with population ranging from 700,500 (Calgary 1991) to just over 10,000 (Wetaskiwin 1991). The Hamlet of Sherwood Park with close to 40,000 population could also be considered as a small city for the purposes of this report. Excluding the larger metropolitan areas of Calgary and Edmonton, the remaining 14 cities have an average population of approximately 20,000 with Red Deer at close to 60,000.

The Small City model has been developed to represent Alberta communities which possess a comprehensive waste management system, maintain staff who are developing strategic programs for waste minimization, and produce the necessary volumes of organic waste to substantiate larger scale compost processing equipment.

It is most likely that these communities have attempted, are in the process of, or are considering the establishment of centralized composting. It is also likely that these communities face considerable logistical problems associated with separation and collection of organics from a much larger and varied waste generator base.

By the same token, the very size of the larger cities provides them the opportunity of developing more than one composting facility of viable scale. These could be located strategically to limit the haul distance to any one, or to capitalize on the differing waste characteristics of particular localities within the city.

Model #4 - Small City Profile

POPULATION:	19,685 (ranges from 10,000 to 60,014)	
RESIDENTIAL:	Number of Dwellings (Average 7022)	7022
	• Single family	5478
	• Mobile home	210
	• Multi-family	1334
COMMERCIAL:	Restaurants	40
	Hotels / Motels	6
	Groceries Retail	8
	Butchers / Meat producers	7
	Bakeries	5
	Banks	8
	Professional Offices	131
	Gas Stations / Convenience	18
	Retail Services	197
	Wholesale Services	33
	Printing	8
	Greenhouse / Market Garden	9
Transportation:	Local airport	1
	Bus depot	1
	Train Station	1
INDUSTRIAL:		
Agricultural:	Grain Elevator	2
Forest:	Depending upon location	
Petro Chemical:	Depending upon location	
Leisure Tourism:	Major Sports complexes	10
	Fairgrounds	1
	Golf Courses	1
	Campgrounds	1
INSTITUTIONAL:	Office buildings (100 employees each)	10
	Educational	13
	Churches	18
	Hospitals (130 beds)	1

Examples include:
Red Deer
Lloydminster
Medicine Hat
Grande Prairie
Ft. McMurray

MODEL #5 - LARGE CITY

General Description:

Alberta's two large cities of Edmonton and Calgary are modelled by virtue of their size and complexity. It is assumed that these centres will face the greatest challenges for waste reduction in the years to come and will invest a great deal of time and energy in looking at large scale municipal compost options to service both local and sub-regional populations. At the same time, smaller scale options (like backyard composting) can promote waste reduction at source. It is also these centres, particularly Edmonton, that will be forced to expedite programs of waste reduction since landfill issues are of paramount concern and the relative costs of alternatives are an issue in times of economic constraint.

While Calgary is reputed to have adequate landfill capacity for the foreseeable future, Edmonton has not. Lack of landfill space is everywhere forcing major cities of North America to expedite programs of waste reduction. The cost of transporting waste to disposal sites and the capital needed to provide alternatives to the rapidly filling landfills are important issues in times of economic constraint.

Model #5 - Large City Profile

POPULATION:	614,665 (Edmonton)	
RESIDENTIAL:	Number of Dwellings (250,000)	250,000
	_ Single family	130,000
	_ Mobile home	2500
	_ Multiple / Apartments	117,500
COMMERCIAL:	Restaurants	1230
	Hotels / Motels	75
	Groceries Retail	240
	Butchers / Meat producers (1 per 10,000)	60
	Bakeries - (1 per 3500)	176
	Banks - (1 per 4000)	154
	Professional Offices	4100
	Gas Stations / Convenience - (1 per 2050)	300
	Food Wholesalers	30
	Printing	245
	Retail Services	6377
	Wholesale Services	784
	Greenhouse / Market Garden	257
	Horticulture / Landscape	50
Transportation:	Major Airports	1
	Major Train Station	1
	Major Bus Terminal	1
INDUSTRIAL:		
Agricultural:	Food processing	14
	Dairies / Creameries	6
Forest:	(considered outside of model)	
Petro Chemical:	(considered outside of model)	
Leisure Tourism:	Sport Facilities	10
	Fairgrounds	1
	Golf Courses	35
	Campgrounds	8
	Special Attractions	5
INSTITUTIONAL:	Government Office buildings (39,775 employees)	
	Educational	96
	Church	560
	Military bases	1
	Prisons	2
	Hospitals	19
	Municipal Waste Handling Facilities	2

Examples:
Edmonton
Calgary

MODEL #6 - RESORT COMMUNITY

General Description:

Resort communities such as Banff and Jasper are unlike the Town models in that their primary industries are tourism rather than forestry or farming. As such, the feedstock from sources such as restaurants, ski resorts, mountain lodges, hotels and motels is found in higher quantities than that expected in non-resort communities. Also of significance is the fact that resort communities experience significant fluctuations in population depending upon the season. The generation of organic wastes will fluctuate with the changing population.

Resort communities will most often be associated with Mountain Parks, bringing protection of the environment into sharp focus. There are also special considerations imposed by the federal authorities, who decide what can and cannot be done within the National Parks.

Model #6 - Resort Community Profile

POPULATION:	8500 (Banff - tourist population inflates to 20,000 during peak seasons)	
RESIDENTIAL:	Number of Dwellings	1600
	• Single family	1000
	• Multiple / apartments	600
COMMERCIAL:	Restaurants	40
	Hotels / Motels	40
	Groceries Retail	5
	Butchers / Meat producers	2
	Bakeries	2
	Banks	7
	Professional Offices	56
	Gas Stations / Convenience	8
	Retail Services	85
	Printing / Publishing	4
	Greenhouse / Market Garden	1
Transportation:	Bus Depot	1
	Train Station	*1*
INDUSTRIAL:	Small industrial park	1
Agricultural:	Insignificant	
Forest:	Insignificant	
Petro Chemical:	Insignificant	
Leisure Tourism:	Sport & Leisure Facilities	2
	Major resorts - (Banff Springs Hotel, Sunshine Ski Area, Norquay Ski Area)	3
	Golf Courses	1
	Campgrounds -(includes National Park)	14
	Special Attractions/Zoos - (includes Hot Springs / museums / art galleries)	*5*
INSTITUTIONAL:	Government office buildings (at 100 per office)	3
	Educational	6
	Churches	6
	Hospitals	1
	Municipal Waste Handling	1
	Public Works / Parks & Open Space	

Examples include:
Banff
Jasper
Canmore
Sylvan Lake

MODEL #7 - INTEGRATED REGION

General Description:

This model has been developed as a means to measure the sustainability of various composting options that could occur within a regional waste district comprised of a number of communities. Typically, regional waste districts in Alberta are managed by a regional authority (or board) made up of representatives from each member municipality or community. Residual wastes from these communities are normally taken to local transfer stations then transported to a larger regional landfill for disposal. Such systems are effective in reducing the number of landfills required and, as a result, environmental impacts are reduced and, in some cases, costs of operations are also reduced.

When it comes to composting, regional waste districts can provide distinct advantages over individual communities. Where smaller communities may not have access to sufficient feedstock to make composting practical, a combination of regional communities may. Also of significance is the fact that most waste systems within Alberta are made up of rural based communities, thus the quantity of agriculturally based feedstock is more present, more site options are available for processing, paper waste can be shredded and utilized as livestock bedding, and markets for the end use of compost are found within the region in the form of farms and community residences and local parks systems.

Where integrated systems are combined with larger urban communities (towns or cities), the feasibility of composting is often improved through a more diverse generator base, through an established transfer system and through a representative system of management which sets the stage for cooperative initiatives.

Close to thirty regional waste management systems are now in place within Alberta. The model chosen for review is most typical in that it combines a town, four villages, two summer villages and an associated rural base.

Model #7 - Integrated Region (Non-Metropolitan)		
POPULATION:	11,000 permanent year round (not including 1000 seasonal cottagers and 53,000 seasonal campers)	
	Breakdown:	
	1 Town:	5,000
	4 Villages:	745
	2 Summer Villages:	55
	Farms or rural pop.	5,200
RESIDENTIAL:	Number of Dwellings:	
	• Town & Village Single family	1690
	• Town & Village Mobile homes	160
	• Town Multiple units / apartments	450
	• Rural Single family	1630
	• Seasonal Cottages	290
	Total Year Round	4220
COMMERCIAL:	Restaurants and food outlets	13
	Hotels / Motels	8
	Groceries Retail	9
	Butchers / Meat producers	3
	Bakeries	2
	Banks	5
	Professional Offices	70
	Gas Stations / Convenience	7
	Retail Services	110
	Wholesale Services	10
	Greenhouse / Market Garden	2
	Landscape Services	2
Transportation:	Bus Depots	4
	Train Station	*1*
INDUSTRIAL:		
Agricultural:	Mixed Farms	84
	Dairy Farms	48
	Feed Lots	400
	Poultry Farms	25
	Grain Farms	600
	Grain Elevators	6
Leisure Tourism:	Sport & Leisure Facilities	2
	Fairgrounds	2
	Campgrounds (comprised of a total 500 campsites)	6
INSTITUTIONAL:	Government office buildings	5
	Educational	6
	Churches	9
	Hospitals	1
	Municipal Waste Handling	1

* An example of this model is the Stettler Integrated Waste Management System

4.3 Typical Feedstock Quantities

Through a comparative analysis of actual generator waste audits (see Appendix 2 in the Technical document) and the mix of generator types within the seven community model categories, typical feedstock quantities and an approximate carbon and nitrogen balance can be estimated (Tables 4.2 to 4.8).

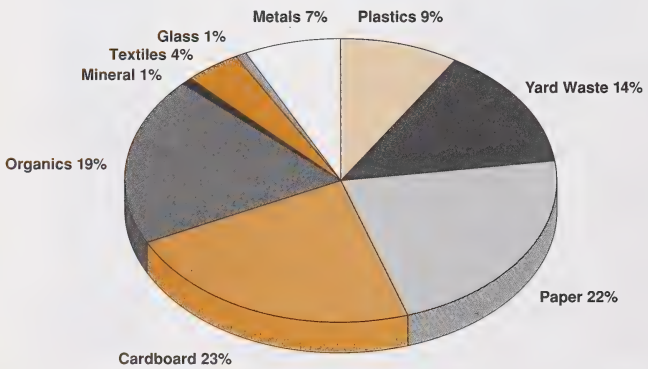
This information is valuable as a means of estimating the level of composting programs required to handle the gross volumes found within an average community. It also serves to demonstrate the available nitrogen and carbon predominance, thereby enabling the establishment of a collection program which targets the desired feedstock for the relative volumes of material to be composted. For example, a community which focuses upon the collection of paper and cardboard waste only will find that the volumes collected represent a carbon rich base that far exceeds the required nitrogen balance (a ratio of 25 or 35 to 1) which can be collected from targeted sources. If this is the case, the community may wish to target a rich nitrogen source within the vicinity as a means to promote an active compost pile (*e.g.*, farmyard manure).

The ratios will vary from community to community. For example, a typical resort community demonstrates a higher than average concentration of food service outlets, thus an increased supply of nitrogen based vegetable and food wastes are available as a valuable feedstock source.

It should be noted that quantities of old corrugated cardboard and paper products like newsprint are included within the feedstock inventory, since they are considered to be valuable compostables if shredded. On the other hand, larger communities which are well entrenched in recycling will be faced with the dilemma of either including or excluding this component. The average municipal waste stream make-up is presented in Figure 3.

Figure 3 - Average Composition of Total Waste Stream - 1990

Source: Master Composter / Recycler Manual, City of Edmonton, 1990



Forty-five percent of the total waste stream is comprised of cardboard and paper of which, under normal circumstances, a good portion is recycled. This will reduce the quantity of compostable feedstock in the average community by the relative amount that finds its way into a recycle program. For example, in Seattle, Washington in 1989, 167,185 tons of cardboard, bond, newsprint and mixed paper, or 25% of its total waste stream was recycled. This represented more than one-half of the city's total paper waste and comprised close to 67% of their materials recovery (7% of recovery program was attributed to composting). In a smaller community, Haddonfield, New Jersey, 13% of its total waste stream was recycled cardboard and paper products (this represented close to 30% of total paper waste) and just over one-quarter of its total materials recovery program (30% of recovery was attributed to composting).*

Seattle, Washington (population 497,000)

Total Waste generated in 1989:	672,024 tons
Total Waste recovered:	243,818 tons (38%)
of which:	42,904 tons (7%) was composted
	200,914 tons (31%) was recycled
	25% paper
	6% other

Haddonfield, New Jersey (population 12,151)

Total Waste generated in 1989:	13,681 tons
Total Waste recovered:	6,678 tons (49%)
of which:	4,207 tons (30%) was composted
	2,417 tons (18.5%) was recycled
	13% paper
	5.5% other

The total capture rate of compostable materials (assuming generators are willing to provide feedstocks) in major centres where most recyclers exist will most likely comprise a lesser percentage of the waste stream than in centres which are located too far from recycle markets to make recycling worthwhile from an economic standpoint.

For example, in a community which either does nothing or little to recycle, the quantity of feedstock will be in excess of 70% of the overall waste stream. Conversely a community such as Seattle, with active recycling of paper products,

* *Beyond 40 Percent, Record Setting recycling and Composting Programs,* Institute for Local Self-Reliance, 1991

the quantity of feedstock may be as low as 35 - 40%. It is also expected that where paper recycling programs are in place, they will be regarded as a higher form of recovery than composting. As such, competition for paper as a compost feedstock rather that a recyclable commodity is not likely to occur under present market conditions.

The inventories of feedstock which have been developed for each community model are provided in Tables 4.2 through 4.8. Also provided are feedstock quantities present in the Agricultural and Forest Product Sectors. These generators are considered to be excellent sources to either augment municipal feedstock, or to complement those composting programs which may focus upon mass production. The available feedstock from a provincial perspective is summarized on Table 4.9. It is of interest to note that in all community generator types, there is sufficient nitrogen and carbon rich feedstock to sustain a community based composting program. Also revealing is the fact that the combined feedstock from Alberta farms and forestry operations is close to 30 times that of the combined totals in the municipal sector.

The upshot of this analysis is that finding an adequate supply of suitable organic material to be the feedstock of a composting operation should not be considered a deterrent to composting in any Alberta community. It may or may not be readily available at an economic transportation rate to a central facility (see 5.3.2). The general quality of the feedstock, in terms of its carbon:nitrogen balance, is variable, but not so as to make it a limitation on active community composting.

Table 4.2 ***Compostable Feedstock Quantities from A Typical VILLAGE***

Feedstock Generators	Kilograms/ Year	Carbon Rich Tonnes	Nitrogen Rich Tonnes	Total Tonnes
RESIDENTIAL:				
Single Family	98,750	59	40	99
Multi Family	35,200	30	5	35
Apartments/ institutional residences/ nursing homes/ seniors residences	-	-	-	-
COMMERCIAL:				
Restaurants/prepared food outlets	7,150	4	3	7
Hotels/Motels	-	-	-	-
Grocery/Supermarkets	43,000	34	9	43
Butchers/Meat Producers	-	-	-	-
Bakeries	-	-	-	-
Banks/Financial Institutions	6,400	6	-	6
Professional Offices	8,100	8	-	8
Gas Stations	3,700	4	-	4
Food Wholesalers	-	-	-	-
Printing/Publishing	-	-	-	-
Services Retail - hardware, clothing	10,500	10	1	11
Services Wholesale - packaging	-	-	-	-
Greenhouses/Market Gardens	-	-	-	-
Horticultural/Landscape Services	-	-	-	-
Transportation - airplanes, trains, buses	-	-	-	-
INDUSTRIAL:				
Agricultural				
Mixed Farms	-	-	-	-
Dairy Farms/Creameries	-	-	-	-
Feedlots	-	-	-	-
Poultry Farms	-	-	-	-
Food Processing Plants	-	-	-	-
Grain Elevators/Mills	-	-	-	-
Sub-Total	212,800	155	58	213

Table 4.2 ***VILLAGE (continued)***

Feedstock Generators	Kilograms/ Year	Carbon Rich Tonnes	Nitrogen Rich Tonnes	Total Tonnes
INDUSTRIAL (continued)				
Forest:				
Logging Operations/Mills	-	-	-	-
Wood Product Industries	-	-	-	-
Petro Chemical:				
Refineries/Gas Plants	-	-	-	-
Seasonal Camps	-	-	-	-
Leisure Tourism:				
Sports & Leisure Facilities	-	-	-	-
Fairgrounds	-	-	-	-
Major Resorts	-	-	-	-
Golf Courses	-	-	-	-
Campgrounds/Day Use	-	-	-	-
Special Attractions/Zoos	-	-	-	-
INSTITUTIONAL:				
Government Offices	15,200	15	-	15
Military Bases	-	-	-	-
Prisons	-	-	-	-
Hospitals	-	-	-	-
Educational Institutions	13,000	12	1	13
Churches	5,750	5	1	6
Municipal Waste handling facilities - Solid	1,000	-	1	1
Municipal Waste handling facilities - Liquid	-	-	-	-
Sub-Total This Page	34,950	32	3	35
Sub-Total from Previous Page	212,800	155	59	213
TOTALS	**247,750**	**187**	**61**	**248**

Table 4.3 ***Compostable Feedstock Quantities from A Typical TOWN / NON-FARM***

Feedstock Generators	Kilograms/ Year	Carbon Rich Tonnes	Nitrogen Rich Tonnes	Total Tonnes
RESIDENTIAL:				
Single Family	632,000	376	256	632
Multi Family	102,000	90	12	102
Apartments/ institutional residences/ nursing homes/ seniors residences	123,000	104	19	123
COMMERCIAL:				
Restaurants/prepared food outlets	175,000	99	76	175
Hotels/Motels	120,000	86	34	120
Grocery/Supermarkets	240,000	187	53	240
Butchers/Meat Producers	157,000	17	140	157
Bakeries	20,850	14	7	21
Banks/Financial Institutions	26,000	26	-	26
Professional Offices	30,000	30	-	30
Gas Stations	5,400	5	-	5
Food Wholesalers	212,000	151	61	212
Printing/Publishing	-	-	-	-
Services Retail - hardware, clothing	61,100	57	4	61
Services Wholesale - packaging	-	-	-	-
Greenhouses/Market Gardens	24,400	24	-	24
Horticultural/Landscape Services	12,500	8	4	12
Transportation - airplanes, trains, buses	5,000	4	1	5
INDUSTRIAL:				
Agricultural				
Mixed Farms	-	-	-	-
Dairy Farms/Creameries	-	-	-	-
Feedlots	-	-	-	-
Poultry Farms	-	-	-	-
Food Processing Plants	-	-	-	-
Grain Elevators/Mills	-	-	-	-
Sub-Total	1,946,250	1,278	667	1,945

Table 4.3 ***TOWN / NON-FARM (continued)***

Feedstock Generators	Kilograms/ Year	Carbon Rich Tonnes	Nitrogen Rich Tonnes	Total Tonnes
INDUSTRIAL (continued)				
Forest:				
Logging Operations/Mills	-	70,000	-	70,000
Wood Product Industries	14,500,000	7,000	7,500	14,500
Petro Chemical:				
Refineries/Gas Plants	2,400	2	1	3
Seasonal Camps	-	-	-	-
Leisure Tourism:				
Sports & Leisure Facilities	56,000	54	2	56
Fairgrounds	41,500	7	34	41
Major Resorts	-	-	-	-
Golf Courses	-	-	-	-
Campgrounds/Day Use	19,450	16	4	20
Special Attractions/Zoos	-	-	-	-
INSTITUTIONAL:				
Government Offices	27,400	27	-	27
Military Bases	-	-	-	-
Prisons	-	-	-	-
Hospitals	46,500	33	14	47
Educational Institutions	167,000	161	6	167
Churches	46,000	40	6	46
Municipal Waste handling facilities - Solid	6,000	-	6	6
Municipal Waste handling facilities - Liquid	-	-	-	-
Sub-Total This Page	84,912,250	77,340	7,573	84,913
Sub-Total from Previous Page	1,946,250	1,278	667	1,945
Total (including Forest)	**86,858,500**	**78,618**	**8,240**	**86,858**

Table 4.4 Compostable Feedstock Quantities from A Typical TOWN / FARM COMMUNITY

Feedstock Generators	Kilograms/ Year	Carbon Rich Tonnes	Nitrogen Rich Tonnes	Total Tonnes
RESIDENTIAL:				
Single Family	632,000	376	256	632
Multi Family	109,000	92	17	109
Apartments/ institutional residences/ nursing homes/ seniors residences	123,000	104	19	123
COMMERCIAL:				
Restaurants/prepared food outlets	175,000	99	76	175
Hotels/Motels	100,000	72	28	100
Grocery/Supermarkets	240,000	187	53	240
Butchers/Meat Producers	157,000	17	140	157
Bakeries	20,850	14	7	21
Banks/Financial Institutions	26,000	26	-	26
Professional Offices	30,000	30	-	30
Gas Stations	5,400	5	-	5
Food Wholesalers	212,000	151	61	212
Printing/Publishing	-	-	-	-
Services Retail - hardware, clothing	61,100	57	4	61
Services Wholesale - packaging	-	-	-	-
Greenhouses/Market Gardens	24,400	24	-	24
Horticultural/Landscape Services	12,500	8	4	12
Transportation - airplanes, trains, buses	5,000	4	1	5
INDUSTRIAL:				
Agricultural				
Mixed Farms	3,005,000	5	3,000	3,005
Dairy Farms/Creameries	131,000	83	48	131
Feedlots	27,000,000	-	27,000	27,000
Poultry Farms	744,000	12	732	744
Food Processing Plants	-	-	-	-
Grain Elevators/Mills	2,000	2	-	2
Farm Households	610,000	464	146	610
Sub-Total	33,425,250	1,832	31,592	33,424

Table 4.4 ***TOWN / FARM COMMUNITY (continued)***

Feedstock Generators	Kilograms/ Year	Carbon Rich Tonnes	Nitrogen Rich Tonnes	Total Tonnes
INDUSTRIAL (continued)				
Forest:				
Logging Operations/Mills	-	-	-	-
Wood Product Industries	-	-	-	-
Petro Chemical:				
Refineries/Gas Plants	-	-	-	-
Seasonal Camps	-	-	-	-
Leisure Tourism:				
Sports & Leisure Facilities	56,000	54	2	56
Fairgrounds	41,500	7	34	41
Major Resorts	-	-	-	-
Golf Courses	-	-	-	-
Campgrounds/Day Use	19,450	16	4	20
Special Attractions/Zoos	-	-	-	-
INSTITUTIONAL:				
Government Offices	27,400	27	-	27
Military Bases	-	-	-	-
Prisons	-	-	-	-
Hospitals	-	-	-	-
Educational Institutions	167,000	161	6	167
Churches	46,000	40	6	46
Municipal Waste handling facilities - Solid	6,000	-	6	6
Municipal Waste handling facilities - Liquid	-	-	-	-
Sub-Total This Page	363,350	305	58	363
Sub-Total from Previous Page	33,425,250	1,832	32,592	33,424
TOTALS	**33,788,600**	**2,137**	**31,650**	**33,787**

Table 4.5 ***Compostable Feedstock Quantities from A Typical Model SMALL CITY***

Feedstock Generators	Kilograms/ Year	Carbon Rich Tonnes	Nitrogen Rich Tonnes	Total Tonnes
RESIDENTIAL:				
Single Family	4,327,600	2,596	1,731	4,327
Multi Family	1,187,000	997	190	1,187
Apartments/ institutional residences/ nursing homes/ seniors residences	260,900	198	63	261
COMMERCIAL:				
Restaurants/prepared food outlets	880,000	493	387	880
Hotels/Motels	248,000	179	69	248
Grocery/Supermarkets	855,000	667	188	855
Butchers/Meat Producers	475,000	52	423	475
Bakeries	133,40	90	43	133
Banks/Financial Institutions	76,000	76	-	76
Professional Offices	98,200	98	-	98
Gas Stations	320,000	320	-	320
Food Wholesalers	-	-	-	-
Printing/Publishing	152,000	152	-	152
Services Retail - hardware, clothing	1,478,000	1,375	103	1,478
Services Wholesale - packaging	920,000	920	-	920
Greenhouses/Market Gardens	206,000	206	-	206
Horticultural/Landscape Services	-	-	-	-
Transportation - airplanes, trains, buses	51,200	51	-	51
INDUSTRIAL:				
Agricultural				
Mixed Farms	-	-	-	-
Dairy Farms/Creameries	-	-	-	-
Feedlots	-	-	-	-
Poultry Farms	-	-	-	-
Food Processing Plants	-	-	-	-
Grain Elevators/Mills	2,000	2	-	2
Sub-Total	11,670,300	8,472	3,197	11,669

Table 4.5 ***SMALL CITY (continued)***

Feedstock Generators	Kilograms/ Year	Carbon Rich Tonnes	Nitrogen Rich Tonnes	Total Tonnes
INDUSTRIAL (continued)				
Forest:				
Logging Operations/Mills	-	-	-	-
Wood Product Industries	-	-	-	-
Petro Chemical:				
Refineries/Gas Plants	-	-	-	-
Seasonal Camps	-	-	-	-
Leisure Tourism:				
Sports & Leisure Facilities	56,000	54	2	56
Fairgrounds	41,500	7	34	41
Major Resorts	-	-	-	-
Golf Courses	-	-	-	-
Campgrounds/Day Use	19,450	16	4	20
Special Attractions/Zoos	-	-	-	-
INSTITUTIONAL:				
Government Offices	27,400	27	-	27
Military Bases	-	-	-	-
Prisons	-	-	-	-
Hospitals	-	-	-	-
Educational Institutions	167,000	161	6	167
Churches	46,000	40	6	46
Municipal Waste handling facilities - Solid	6,000	-	6	6
Municipal Waste handling facilities - Liquid	-	-	-	-
Sub-Total This Page	363,350	305	58	363
Sub-Total from Previous Page	33,425,250	1,832	32,592	33,424
TOTALS	**33,788,600**	**2,137**	**31,650**	**33,787**

Table 4.6 ***Compostable Feedstock Quantities from A Typical Model LARGE CITY***

Feedstock Generators	Carbon Rich Tonnes	Nitrogen Rich Tonnes	Total Tonnes
RESIDENTIAL:			
Single Family	62,000	41,000	103,000
Multi Family	87,000	17,000	104,000
Apartments/ institutional residences/ nursing homes/ seniors residences	1,520	480	2,000
COMMERCIAL:			
Restaurants/prepared food outlets	20,160	15,840	36,000
Hotels/Motels	3,380	1,320	4,700
Grocery/Supermarkets	32,000	9,000	41,000
Butchers/Meat Producers	1,000	8,000	9,000
Bakeries	2,475	1,225	3,700
Banks/Financial Institutions	2,000	-	2,000
Professional Offices	61,000	-	61,000
Gas Stations	600	-	600
Food Wholesalers	4,300	1,700	6,000
Printing/Publishing	6,000	-	6,000
Services Retail - hardware, clothing	28,000	2,000	30,000
Services Wholesale - packaging	22,000	-	22,000
Greenhouses/Market Gardens	6,400	-	6,400
Horticultural/Landscape Services	442	208	650
Transportation - airplanes, trains, buses	700	500	1,200
INDUSTRIAL:			
Agricultural			
Mixed Farms	-	-	-
Dairy Farms/Creameries	160	92	252
Feedlots	-	-	-
Poultry Farms	-	-	-
Food Processing Plants	1,700	4002,100	
Grain Elevators/Mills	-	-	-
Sub-Total	342,837	98,765	441,602

Table 4.6 ***LARGE CITY (continued)***

Feedstock Generators	Carbon Rich Tonnes	Nitrogen Rich Tonnes	Total Tonnes
INDUSTRIAL (continued)			
Forest:			
Logging Operations/Mills	-	-	-
Wood Product Industries	-	-	-
Petro Chemical:			
Refineries/Gas Plants	-	--	
Seasonal Camps	-	-	-
Leisure Tourism:			
Sports & Leisure Facilities	260	20	280
Fairgrounds	8	33	41
Major Resorts	-	-	-
Golf Courses	2,500	1,500	4,000
Campgrounds/Day Use	120	40	160
Special Attractions/Zoos	510	50	560
INSTITUTIONAL:			
Government Offices	7,200	-	7,200
Military Bases	449	431	880
Prisons	185	255	440
Hospitals	612	262	874
Educational Institutions	4,800	200	5,000
Churches	10,000	1,900	11,900
Municipal Waste handling facilities - Solid	-	18,000	18,000
Municipal Waste handling facilities - Liquid	-	-	-
Sub-Total This Page	26,664	22,691	49,355
Sub-Total from Previous Page	342,837	98,765	441,602
TOTALS	**369,501**	**121,456**	**490,957**

Table 4.7 ***Compostable Feedstock Quantities from A Typical Model RESORT***

Feedstock Generators	Kilograms/ Year	Carbon Rich Tonnes	Nitrogen Rich Tonnes	Total Tonnes
RESIDENTIAL:				
Single Family	790,000	474	316	790
Multi Family	534,000	449	85	534
Apartments/ institutional residences/ nursing homes/ seniors residences	-	-	-	-
COMMERCIAL:				
Restaurants/prepared food outlets	1,220,000	683	537	1,220
Hotels/Motels	1,600,000	1,152	448	1,600
Grocery/Supermarkets	615,000	480	135	615
Butchers/Meat Producers	64,000	7	57	64
Bakeries	43,000	29	14	43
Banks/Financial Institutions	84,000	84	-	84
Professional Offices	40,800	41	-	41
Gas Stations	15,000	15	-	15
Food Wholesalers	-	-	-	-
Printing/Publishing	102,000	102	-	102
Services Retail - hardware, clothing	925,000	860	65	925
Services Wholesale - packaging	-	-	-	-
Greenhouses/Market Gardens	25,000	25	-	25
Horticultural/Landscape Services/Public Work	38,000	23	15	38
Transportation - airplanes, trains, buses	36,000	31	5	36
INDUSTRIAL:				
Agricultural				
Mixed Farms	-	-	-	-
Dairy Farms/Creameries	-	-	-	-
Feedlots	-	-	-	-
Poultry Farms	-	-	-	-
Food Processing Plants	-	-	-	-
Grain Elevators/Mills	-	-	-	-
Sub-Total	6,131,800	4,455	1,677	6,132

Table 4.7 ***RESORT (continued)***

Feedstock Generators	Kilograms/ Year	Carbon Rich Tonnes	Nitrogen Rich Tonnes	Total Tonnes
INDUSTRIAL (continued)				
Forest:				
Logging Operations/Mills	-	-	-	-
Wood Product Industries	-	-	-	-
Petro Chemical:				
Refineries/Gas Plants	-	-	-	-
Seasonal Camps	-	-	-	-
Leisure Tourism:				
Sports & Leisure Facilities	57,000	54	3	57
Fairgrounds	-	-	-	-
Major Resort	1,105,00	690	415	1,105
Golf Courses	166,400	100	66	166
Campgrounds/Day Use	273,000	218	55	273
Special Attractions/Zoos	265,000	244	21	265
INSTITUTIONAL:				
Government Offices	56,000	56	-	56
Military Bases	-	-	-	-
Prisons	-	-	-	-
Hospitals	35,000	25	10	35
Educational Institutions	-	-	-	-
Churches	-	-	-	-
Municipal Waste handling facilities - Solid	123,000	-	123	123
Municipal Waste handling facilities - Liquid	-	-	-	-
Sub-Total This Page	2,080,400	1,387	693	2,080
Sub-Total from Previous Page	6,131,800	4,455	1,677	6,132
TOTALS	**8,212,200**	**5,842**	**2,370**	**8,212**

Table 4.8 ***Compostable Feedstock Quantities from A Typical INTEGRATED REGION (Non-Metropolitan)***

Feedstock Generators	Kilograms/ Year	Carbon Rich Tonnes	Nitrogen Rich Tonnes	Total Tonnes
RESIDENTIAL:				
Single Family	1,335,000	801	534	1,335
Multi Family	142,000	120	22	142
Apartments/ institutional residences/ nursing homes/ seniors residences	568,000	433	136	568
Seasonal and Rural	758,000	451	307	758
COMMERCIAL:				
Restaurants/prepared food outlets (13)	364,000	208	156	364
Hotels/Motels (4)	248,000	180	68	248
Grocery/Supermarkets (4)	684,000	536	148	684
Butchers/Meat Producers (inc Grocery)	-	-	-	-
Bakeries (inc Grocery)	-	-	-	-
Banks/Financial Institutions (5)	-	-	-	-
Professional Offices (10)	152,000	152	-	152
Gas Stations (7)	13,000	13	-	13
Food Wholesalers	-	-	-	-
Printing/Publishing	-	-	-	-
Services Retail - hardware, clothing (14)	240,400	224	16	240
Services Wholesale - packaging (10)	279,000	279	-	279
Greenhouses/Market Gardens (2)	50,800	51	-	51
Horticultural/Landscape Services (2)	25,000	17	8	25
Transportation - airplanes, trains, buses (inc Services Retail)	-	-	-	-
INDUSTRIAL:				
Agricultural				
Mixed Farms (84)	-	-	-	-
Dairy Farms/Creameries (48)	-	-	-	-
Feedlots (400)	-	-	-	-
Poultry Farms (25)	-	-	-	-
Food Processing Plants	-	-	-	-
Grain Elevators/Mills (6)	12,000	12	-	12
Sub-Total	4,871,200	3,477	1,395	4,872

Table 4.8 ***INTEGRATED REGION (continued)***

Feedstock Generators	Kilograms/ Year	Carbon Rich Tonnes	Nitrogen Rich Tonnes	Total Tonnes
INDUSTRIAL (continued)				
Forest:				
Logging Operations/Mills	-	-	-	-
Wood Product Industries	-	-	-	-
Petro Chemical:				
Refineries/Gas Plants	-	-	-	-
Seasonal Camps	-	-	-	-
Leisure Tourism:				
Sports & Leisure Facilities (2)	56,600	53	4	57
Fairgrounds (2)	81,250	14	67	81
Major Resorts	-	-	-	-
Golf Courses	-	-	-	-
Campgrounds/Day Use (6)	114,000	94	20	114
Special Attractions/Zoos	-	-	-	-
INSTITUTIONAL:				
Government Offices (2)	27,000	27	-	27
Military Bases	-	-	-	-
Prisons	-	-	-	-
Hospitals	46,500	32	14	46
Educational Institutions (6)	336,000	324	12	336
Churches (9)	207,000	176	31	207
Municipal Waste handling facilities - Solid	-	-	-	-
Municipal Waste handling facilities - Liquid	-	-	-	-
Sub-Total This Page	868,350	720	148	868
Sub-Total from Previous Page	4,871,200	3,477	1,395	4,872
TOTALS	**5,739,550**	**4,197**	**1,543**	**5,740**

Note:
- An example of this model is the Stettler Waste Management System
- Seasonal and rural population 1920 — .5 MT / household / year
- Agriculture manures and municipal solid sewage septage not included

Residential 2803 MT / year
ICI 2936 MT / year
5739 MT / year total - total average waste 7436 MT / year or 77% of total is compostable

Table 4.9 ***Summary of Alberta Feedstock Quantities[1]***

Source Models	Population 1992	Feedstock Tonnes	Carbon Rich Feedstock		Nitrogen Rich Feedstock	
			%	Tonnes	%	Tonnes
Municipal / ICI	**Residents**					
Villages	44,273	27,454	75	20,590	25	6,864
Towns	34,904	256,680	69	177,109	31	79,571
Resorts	21,250	20,530	71	14,576	29	5,954
Small Cities	363,912	247,807	72	178,421	28	69,386
Large Cities	1,335,328	1,065,377	75	799,033	25	266,344
Farms	171,800	106,000	70	74,200	30	31,800
Sub-Total	2,271,467 [2]	1,723,848	73.3	1,263,929	26.7	459,919
Farms[3]	**Livestock**					
Cattle	4,700,000	42,347,000	-	-	100	42,347,000
Hogs	1,700,000	3,102,500	-	-	100	3,102,500
Sheep	300,000	219,000	-	-	100	219,000
Goat	20,000	24,800	-	-	100	24,800
Horse	110,000	865,700	-	-	100	865,700
Hen/Chick	8,700,000	226,200	-	-	100	226,200
Other poultry	1,000,000	58,000	-	-	100	58,000
Sub-Total		46,843,200			100	46,843,200
Forestry						
Alberta Wood Industry Residue[4]		1,399,642	92	1,287,671	8	111,971
Total of all Feedstocks		**49,966,690**	**5**	**2,551,600**	**95**	**47,415,090**

1. Includes all organics and includes items that are now fully or partially recycled like Old Corrugated Cardboard (OCC), paper and newsprint.
2. Population unaccounted reside in widespread portions of IDs, MDs, Counties, Reserves, Settlements, and Special areas.
3. The University of Moncton per species animal waste figures (Composting Its Role in Industrial Waste Management, 1991) were utilized as multipliers.
4. From Alberta Sawmill Waste Disposal Task Force, 1991 report.

With the concern expressed virtually everywhere in the province about the need to conserve space in landfills, composting has come into sharp focus as a viable strategy for diversion of organics from the waste stream. At the level of the household, one county in California reports an annual drop of 750 lbs (340 kg) in wastes generated per home, a reduction of 25%[11] through home-level recycling and composting. In selected businesses there can be similar reductions that, as well as relieving the pressure on landfills, save industrial costs and so increase the commercial profitability of the business. The Composting Task Force of the Grocery Industry Committee on Solid Waste reported in October 1991 that disposal of food wastes and containers from retailers in its organization cost them more than $480 million a year, the pre-tax profit on $34 billion of grocery retail sales, and that 89% of this could be composted.[12] This is not merely a theoretical concept. Anheuser-Busch brewery in New York State saved $3.3 million in landfill tipping fees alone by diverting process biosolids to a composting operation, freeing up some 70,000 m3 of landfill space into the bargain.[13]

5.1 Current Issues

The Province of Alberta does not have the same population and climate as California, nor a brewery as large as Anheuser-Busch in Baldwinsville, NY. But Mr. Chuck Davis, the environmental health officer for Wright County in Minnesota with a population of 70,000 and a climate very similar to much of Alberta, states that the volume of Municipal Solid Waste going to the landfill in his county has been reduced 60% to 65% since they introduced mechanically assisted composting a little more than a year ago.[14] This corresponds closely with the generalized figures quoted at 3.2.1. The University of Toronto reports a diversion of about 220 kg per household as a result of backyard composting by a sample population in Hamilton-Wentworth,[15] a reduction of some 12% achieved by targeting food and yard wastes for composting at the scale of a home operation.

The University of Moncton has estimated that the supermarkets, small groceries and convenience stores in New Brunswick generate 3,600 tonnes of food waste residues and over 10,000 tonnes of compostable packaging, from a population of 724,000.[16] This would suggest, from a comparison of populations above, that very substantial savings could be made in landfill capacity and in commercial costs, by composting on a wide scale in Alberta, a province three times as populous.

The benefits compost brings to the soil are well attested, and have been discussed widely in the literature.[17] Although its value as a fertilizer on a tonnage basis is low compared with that of chemical fertilizers, its value as a growth medium and soil conditioner is superior to that of peat moss and many other available substances. Compost is particularly attractive for sandy, acidic, clayey, porous and chalky soils. The utilization of mature compost greatly enhances the physical, chemical and biological properties of the soil and assists in the retention of applied nutrients and water. The industrial sectors most favourable to composting are intensive growing systems such as tree nurseries, fruit nurseries, horticulture, landscaping, sod farming, etc, with mushroom farming representing a special subset of these industries. The different levels at which compost may be applied to land according to its use are shown in the table below, adapted from the World Health Organization's publication on composting as a waste management strategy:

Table 5.1

Levels of Application of Compost to Land According to its Use

Type of Application	Quantity (kg/m2)
Cereal agriculture	2 - 10
Root crops cultivation	5 - 25
Forage crop cultivation	5 - 20
Grazing-land	2 - 5
Fruit orchard	10 - 50
Vegetable cultivation (outdoor)	10 - 50
Decorative plant cultivation	20 - 50
Nursery	10 - 30
Gardens and landscaping	30 - 60
Playing fields	5 - 40

Compared to simple surface application to the land, as in traditional "manure-spreading", the availability of the important nutrients nitrogen, phosphorus and potassium (N,P,K) is improved by composting both farm manures[18] [19] [20] and sludges[21]. So at a time when concern is widely expressed about the effects of chemical fertilizer on agricultural soil and on water resources, and of unprocessed agricultural wastes on water courses and aquifers[22], the relatively benign effects of composting as an alternative strategy for soil remediation are a matter for serious examination.

5.2 General Concerns Affecting Community Health

These benefits are not without their share of related concerns, which address potential hazards to health and safety of people employed in the composting operations as well as those who live nearby, and possible damage to the environment which can again (through the groundwater, for instance, or contaminated root crops) affect people's health. The WHO Handbook summarizes the major concerns.

5.2.1 Sanitization

A good compost should not contain significant quantities of viable pathogenic organisms or weed seeds. These are killed off in a space of two to three days at temperatures in excess of 60°C. A similar degree of sanitization can be achieved at lower process temperatures of 50° - 60°C but it takes longer, perhaps ten to twenty days. Pathogens may also be destroyed by non-pathogenic microbes competing for a limited supply of nutrients in the composting biomass. Fungi which grow during the curing stages of the process are probably producing antibiotics which further ensure the safety of the final product.

If the composting is done too quickly there may be insufficient decomposition of the wastes, allowing a subsequent re-invasion by pathogens from equipment, flies, vermin or birds. Satisfactory lasting sanitization is better achieved in municipal solid wastes, sewage and animal wastes by maintaining the composting materials at a temperature in the 55° - 60°C range over a period of two to three *weeks*, ensuring optimal rates of decomposition.

Some materials may not suffer from these infestations of unwanted life forms - a mixture of brewery wastes and clean leaves, for example. These lower composting temperatures might be advantageous, in view of the greater microbial activity that takes place in a composting biomass at 30° - 55°C. This concept of "mesophilic" composting has been discussed by Finstein (1986)[23], in which a temperature ceiling of 37°C is established, leading to a richer diversity in the microbial community and so improving the efficiency of the composting process. But it takes much longer to produce an acceptable compost in such a regime.

Various techniques can be employed to ensure that all portions of the compost are exposed to the elevated temperatures necessary for sanitization and that no micro-organisms escape pasteurization in the cool outer portions of a composting heap. These techniques include frequent turning, placing insulating layers of mature compost on the outside of the piles, forced aeration and provision of sufficient time for curing. Human and animal pathogens, parasites, spores and eggs may be killed by a combination of temperature and time. Therefore, the operating logs for individual batches of compost showing both time and temperature should be carefully recorded and kept as an indication of the hygienic quality of the product.

5.2.2 Micropollutants in Compost

Consideration must be given to the presence of toxic substances, particularly salts of metals such as mercury, cadmium, copper and zinc, as well as borates. The main non-industrial sources of mercury in municipal solid wastes appear to be rechargeable batteries.[24] Cadmium is widely used as a pigment and stabilizer in paints and plastics and as a protective coating for metal parts. Copper and zinc salts are derived from pigments and dyes as well as from corrosion of the metals. Borates are used in adhesives for paper board. These substances occur in small but recognizable quantities in natural soil and even on yard wastes collected from an urban environment, the products of lawn mower exhausts and stack gases from nearby industries. All are as likely to occur, albeit in differing proportions, in the wastes of a small rural community as of a larger urban centre.

Although copper and zinc are essential elements for plant growth, and in fact compost can be an important source of these elements for certain crops, it should be noted that in excess the soluble salts are toxic and inhibit plant growth. Cadmium is taken up by plant roots and is present at the highest levels in the leaves of vegetables, including lettuce. Cadmium has been identified as the element in food that is most likely to exceed acceptable levels, such as those suggested by the World Health Organization (1979), and is reported to be the only such metal now contained in sewage sludge in significant quantity to concern the City of Edmonton's Environment Department.[25] Acceptable levels of cadmium in compost depend on the species of plants grown, on the pH and on other constituents of the soil. High pH produced by lime or by the alkaline effect of compost reduces the uptake of cadmium by plant roots. Other heavy metals, such as lead, have been found by the US Department of Agriculture to be made less accessible to leaf vegetables by the composting process.[26]

Although toxic organic micropollutants such as pesticides and polycyclic aromatic hydrocarbons are of minor concern in compost derived from domestic refuse, it should be noted that persistent organic materials such as pesticides and polychlorinated biphenyls (*PCBs*) in compost could accumulate in food chains (biomagnification). Synthetic volatile organic compounds (*VOCs*) may also be emitted when municipal solid wastes are composted, especially if there is inadequate sorting of the components of the waste stream before they enter the composting process. These include such compounds as acetone, benzene and toluene used in many industrial processes. The presence of these compounds in the atmosphere where the staff of a composting plant are constantly working is a matter for concern. However, a recent study at the University of Washington suggested that they are well below the levels set for Occupational Safety and Health of American workers in industrial atmospheres.[27] The results are summarized in Table 5.2.

5.2.3 Airborne Microorganisms

Although proper composting will destroy pathogenic organisms and weed seeds, concern has been expressed regarding the spores of fungi which may become airborne and could cause respiratory distress to workers at or near

Table 5.2 ***Occupational Air Standard for Target VOCs and Maximum Levels Observed in MSW Composting Facilities***

Pollutant	Occupational Safety and Health Administration (U.S.A.) Permissible Exposure Limit		Maximum Concentration Observed
	Time-Weighted Average (mg/m3)	*Short-Term Exposure Limit (mg/m3)*	*(mg/m3)*
Acetone	1800	2400	166
Benzene	3.2	16	0.7
Dichloromethane	1730	*3460	0.26
Ethylbenzene	435	545	180
Tetrachloroethylene	170	-	5.6
Trichloroethylene	270	1080	1.3
Toluene	375	560	66
Xylenes	435	655	22

* *Ceiling Value*

compost operations. The thermophilic actinomycetes, bacilli and fungi which bring about the composting process produce a large number of spores that easily become airborne when the composting mass is disturbed. Numbers of fungi and of thermophilic actinomycetes greatly increase during the final stages of composting. Workers on or near compost piles are therefore exposed to large numbers of potentially allergenic microorganisms and hence consideration must be given to this potential hazard.

One of these, ***Aspergillus fumigatus***, has been the subject of much recent discussion.[28] It is a naturally-occurring, pervasive organism that is capable of inducing disease at background environmental concentrations, in individuals predisposed to allergies. The precise dose required to trigger adverse health effects in either healthy or sensitive individuals has not been determined. Humans vary in their susceptibility to pathogens, depending on route of exposure, age of exposed individual, quality of normal bodily defense systems, existing microbial populations in the person's lungs, and so on. Workers at composting facilities are exposed to far higher levels of compost-related contaminants than the general population.

A. fumigatus levels at compost facilities appear to vary widely, and are dependent largely on the specific operation being performed. Recycling of woodchips within the composting process tends to generate the highest levels of fugitive spores, which are largely captured in the biofilter of an enclosed composting process. They are released to the atmosphere in open windrowing, but rapidly become diluted by dispersion. On average ***A. fumigatus*** levels are reported in the literature to be approximately 10 times higher than those found in background environments. These concentrations fall to background levels within approximately 150 metres of the composting activities. Factors such as the extent of facility enclosure and type of composting technology used affect the mobility of ***A. fumigatus*** spores.[29]

A review of literature and facility studies finds that there is no evidence to support the assertion of adverse health effects being greater in composting plants than in many other industrial atmospheres. In general, researchers at the University of Cincinnati have concluded that composting of municipal solid wastes, sludge and yard wastes poses negligible health risks to the workers and those living close by.[30]

5.2.4 Control of Odours and Insects

Depending on how much oxygen is available in the process, malodourous substances might be produced through aerobic composting or through anaerobic digestion. Aerobic respiration yields predominantly CO_2, H_2O and a stabilized organic residue. However, anaerobic digestion may yield

various reduced inorganic or organic end products, some of which are highly volatile and have a strong unpleasant odour, especially those containing sulphur or nitrogen in the molecule.

In windrow systems, odour emissions will be made worse when the windrows are disturbed for further processing, such as in the regular turning procedure. Although the aerated static pile process can also generate odours, this problem can be contained by an adequate depth of cover material, for example matured compost, on the piles. However, given adequate process control, it is unlikely that the aerated static pile system will have a serious odour problem. Insect problems are also minimized by covering the composting pile with a layer of matured compost. This will also insulate the active biomass, ensuring that high temperatures are reached throughout the raw compost. Containment of composting refuse in systems such as a vertical or horizontal reactor facilitates odour and insect control.[31]

All too often, odour problems are due to poorly designed or inadequately operated plants. The most basic preventive measure against malodour is to design and operate facilities to maximize the rate of aerobic decomposition by ensuring the presence of sufficient oxygen and the maintenance of a biologically favourable temperature. Care must be taken in selecting sites for composting plants. Odours cannot be totally eliminated under all weather conditions, so plants should not be located next door to residential or commercial buildings whose occupants may have cause to complain if some bad odours are emitted. Siting a compost plant adjacent to a sewage treatment works offers many advantages if the sewage sludge is to be composted along with the solid waste. Siting near to a landfill can also be advantageous., since the odours inseparable from any waste handling procedure are already part of its established environment. The compost plant at the University of Guelph is absolutely next door to the cattle sheds of the Department of Animal Husbandry, and most people are unaware of its presence. The odours are similar to those accepted as part of the activity of the Department, and do not give rise to adverse comment or objections.

5.2.5 Control of Rodents

Rats and other rodents have been reported to be attracted to composting operations. In the hard winter of 1992/93 this was perceived to be a problem in Toronto and in Winnipeg, where backyard composting has become well established. While rats are not considered to be a problem in Alberta, it may also be noted that the influx of rodents has since been subjected to rigorous investigation and is now regarded as a non-issue that cannot be substantiated by facts.[32]

5.2.6 Inert Contaminants

To obtain a good quality compost, one must also avoid high contents of small inert materials such as pieces of glass, plastics, textiles, metals and partially decomposed paper. These contaminants may render the compost unsuitable for agricultural or horticultural uses, though not to the same degree in large soil amendment programs such as those undertaken by coal mines or pipeline companies.

In many existing refuse composting plants, the refuse is either hammer-milled or shredded to improve its material handling characteristics, which often results in a large amount of small pieces of glass, plastic, metal and batteries being lodged in the putrescible, or compostable fraction, as well as resulting in a distribution of the putrescibles into the non-compostable fraction. This problem may be overcome by pre-screening the raw refuse prior to milling or shredding, and recent developments in refuse processing technologies strongly favour the separation of the constituents of refuse according to their physical size prior to intensive processing. However, some operators prefer to keep such bulky material in the active composting biomass to maintain air passages, and screen them out at the end of the process.

5.3 Local Issues Affecting Design and Operation

These and other related issues were discussed at a recent meeting of senior public health inspectors from different parts of the province, and it was concluded that health concerns can be addressed by a properly designed, maintained and monitored composting operation.[33] The concentration of pesticides and herbicides on samples of compost examined was reported to be well below food tolerance levels and toxicity levels that would inhibit seed germination or plant growth.[34] The problems of storing leaves and other organic wastes in plastic bags, which can lead to anaerobic conditions producing odour and unacceptable quantities of plastic in the compost, can be overcome by the use of suitable paper bags that degrade at the same rate as the leaves.[35] Numbers of these have been developed specifically for the use of compostors and are marketed throughout Canada.[36] The groundwater can be adequately protected by suitably sealed composting areas and run-off collection ponds.

Nonetheless, if composting is to achieve anything like its full potential in urban and rural Alberta, a number of local issues have still to be addressed.

5.3.1 Accessibility of Suitable Compost Feedstock

Separation of wastes suitable for composting from the potential contaminants in the waste stream is known to produce superior compost.[37] Yet only a relatively small part

of our population is now carrying out any extensive form of separation of wastes at source. Even communities that have instituted a form of wet/dry separation to assist recycling and composting are left with some residual problems in handling these waste streams. A report assessing the effectiveness of such an operation in Ontario notes that significant quantities of household hazardous wastes have been found in the organic stream, including "sharps" such as razor blades and hypodermic needles.[38] Elsewhere in Canada, diapers have remained largely unopened during the composting process in at least one pilot scheme and have been diverted from the ongoing program,[39] although a different process reports that they compost very well.[40] It is clear that a concerted program of public education will be needed if the benefits of the composting process are to be fully realized throughout the province.

Similarly, while composting farmyard manures has been shown to produce a better soil amendment than traditional manure spreading, re-routing the manure to a composting operation will involve considerable re-organization of many established farm practices.[41] Large dairy farms may find it preferable to have a composting operation on their own premises, managed by their own staff or by an outside specialist contractor. This minimizes the re-organization needed, since all the farmyard wastes remain on the premises where they originate. Moreover, the composting program is then deemed to be a practical method of prudent materials management on the farm, and the protracted procedure for permitting by the licensing authorities is much reduced in scope. Increasingly, other jurisdictions in the United States and in Canada are relaxing the protracted permitting process for farm composting even if materials are brought to the site from other sources, provided the resulting compost is used on the farm where it is made.[42]

Experience of farm-based composting operations at several locations in the United States shows that these can often be expanded from their homespun beginnings into profitable industries, providing a much wider service to private sector and municipal clients once the basic composting skills have been developed at the local level. Table 5.3 traces the development of a number of small commercial composting operations, mostly in the United States, which have found such incremental growth both manageable and profitable.

Care must be taken not to expand too quickly. The operator of one such facility reports that, as its reputation grew, waste haulers from an increasingly wide radius began to appear at its weighbridge bringing quantities they could not handle and had to turn away.[44]

Table 5.3 Composters with Interesting C/N Mixes

Name of Operator	Primary materials	Subsequent add-ons
Able Sanitation Grand Rapids, Michigan	Groceries from D+W Food Center	Newspaper, broken pallets
Westminster Farms Central Massachusetts	Manure from 1/2 million chickens	Cranberry presscake, paper waste, lab animal bedding
Grandview Nurseries North Huntingdon, Pennsylvania	Chicken remains + sawdust	Horse manure and bedding, brewery wastes, yardwaste
Cedar Grove, Seattle, Washington	Yard waste	Biosolids, waste paper, food wastes
Gerster Farms Davenport, New York	Manure + waste wood fibre	Cardboard, yardwastes
Webb Family Farms Pittston, Maine	Horse and cow manure + paper used as bedding	Phone books, food wastes from Hannaford Bros stores
Iddings Topsoil Kent, Washington	Yard waste	Food wastes from Larry's Markets, paper from Boeing
Village of Hensall Central Ontario	Grain elevator screenings	Selected clean organics

5.3.2 Collection and Transportation

The change in traditional practice becomes more far-reaching if a number of farms in a region decide to organize a collective composting operation, to which the wastes from each farm will be hauled. Similar considerations will apply to any centralized composting operation that requires collection of the compostable organics separately from the other wastes and may, perhaps, wish to bring in manure or other wastes from the farms in the vicinity. While composting the manure appears to enlarge the economic delivery radius by a factor of about 15[45], haulage of the raw manure imposes a cost and an organizational element that must be carefully considered.

Experience in Alberta with the best methods of collecting compostables is still building up, as indeed it is in much of Canada. A recent survey in the United States by the Institute for Local Self-Reliance in Washington, DC concentrated on a number of record-breaking Recycling and Composting programs where waste diversion goals of more than 40% were being met. These are not yet typical of US municipalities, but they do indicate what can be achieved, and they all show a marked reduction in overall refuse disposal costs by having the collection of compostable material integrated with conventional waste collection and disposal. Among their findings they report:

> *When Takoma Park started its curbside program, it reorganized the Sanitation Division in order to avoid hiring additional employees to collect recyclables. The city reduced the number of trucks collecting refuse and converted one of its three-person refuse collection crews to a recycling crew. After reaching a thirty-six percent residential recovery rate in 1990, Takoma Park further reduced its refuse collection infrastructure in 1991, and split sanitation crews evenly between recycling and refuse collection.*
>
> *Some communities use co-collection systems, in which refuse and source-separated recyclables are collected simultaneously in the same vehicles, in order to more fully integrate recycling into existing solid waste management systems. Loveland, Colorado, projects that its citywide co-collection program will cost $79 a ton - well below the costs estimated for separate trash and recycling collection systems. Baltimore, Maryland, uses the same conventional trash trucks to collect bagged recyclables and garbage, but does so separately at different times. This minimized its upfront costs and allowed it to add a recycling program with no increase in its solid waste management budget.*[46]

It is widely held that collection of source separated wastes, an important consideration in producing compost of the highest quality, will inevitably add to transportation costs. These well documented examples show that some communities have achieved it economically. A number of successful combinations of public service and self-help are discussed at 7.2.

The distance from a central composting plant to its main markets will also impose costs of transportation on the price of the finished product. Referring back to the grown-up farm-based operations listed in Table 5.3, it is noteworthy that in the much more densely populated area of central Massachusetts, it was found that "a 60-mile service radius was a cost effective limit for transporting compostables".[47] There are successful commercial composting operations in Europe where the feedstock is hauled hundreds of kilometres, for instance from Germany where it is made to Spain where it is sold. Another operator of a self-help program, Grandview Nurseries in North Huntingdon, Pennsylvania, reports that transportation has presented no problem to the development of their business. People continue to deliver compostable materials to their facility as a way of getting rid of it, and the surplus of compost that cannot be used in the nursery is sold to people who come and collect it themselves at US$16 a cubic yard - or about CN$55/tonne.[48]

At Olds, a cooperative venture developed between the college and the town has resulted in bins being placed at strategic points throughout the urban centre and a drop-off point at the College Farm where citizens can bring their yard waste on a voluntary basis. This volunteer transport at the local level appears to work very well, and is rewarded by making compost available to the townspeople in return. Brooks maintains two community drop-off sites, one in the town and one near the landfill, where residents can leave yard wastes and tree trimmings. These are reduced to compostable size by the Parks Department and composted, with locally available manure to improve the mix. The City of Red Deer has a windrow pilot project under way, also using manure to improve the compostability of the yard wastes, but is uncertain whether funds will be available to continue it. Given a level of goodwill, similar schemes could no doubt be made to work for other communities elsewhere.

5.3.3 Competition for the Feedstock

While it is obviously in the interests of the overall Green Plan that compostable material should be diverted from the landfill, it is not always obvious that a composting operation is the best direction for it to go. Anheuser-Busch breweries find composting the best solution for their biowastes in New York, but in Edmonton, Molson's Brewery already has an established diversion to a cattle farmer. Similarly the Red Hat Greenhouse Cooperative in southern Alberta and others like it send some of their waste materials to a local composter, but the bulk of spoiled produce and green trimmings go to nearby farmers as cattle feed.[49] Similar

re-routing to an alternative consumer is reported by a major fresh food processor in Edmonton. This represents a higher form of recycling than composting, and will therefore continue to be the prior call on these materials if there is competition for feedstock for a centralized facility. But composting is always preferable to landfilling such wastes.

5.3.4 Climate

Composting is known to work well in tropical and temperate regions, but concerns linger about its ability to continue on a year-round basis in the Alberta climate. Certainly Olds College does not experience much activity in its simple farm-yard manure composting operation through the colder months of the year.

However, a farmer in Idaho reports satisfactory year-round working of his windrows despite low winter temperatures not unlike Alberta's[50] and Summit County in Colorado continues to compost sludge in winter with an average snowfall of 400 cm[51]. Still at the comparatively low-tech end of the scale, Frost Valley YMCA in upstate New York composts its foods wastes year round in an unheated building, with winter temperatures of -30°C[52] and a large yard waste composter who operates several sites in Ontario reports no significant diminution of winter activity at 20°C below with snow on top of his windrows[53].

A brief review of more mechanized operations confirms the ability of well managed composting to continue generating its own winter warmth. The Wright County composting site near Minneapolis[54] pre-treats MSW in a Buhler system, and windrows successfully year round in an open-sided hangar. One of Professor Jack Pos' channel systems developed at the University of Guelph has been in operation in Yellowknife for years. Elsewhere, in-vessel composting is known to be sustainable year-round in the Swiss Alps and on the Arctic Circle of Norway.[55]

5.3.5 Possibility of Oversupply

While farmers in France and householders in Holland have been using compost derived from MSW for a generation, the concept is relatively new to Alberta. A few specialized markets have become established, such as that for mushroom compost. Olds College is providing composted steer manure to a landscape materials wholesaler, and a rancher in the Bentley area reports an active market for his similar product[56]. The concern therefore arises, if many communities suddenly start to produce compost all over the province, will there not be a dramatic oversupply? Fluctuation in the market for recycled paper and plastic, which is known to respond sharply to supply, gives added weight to this very real concern. Many commercial composters plan the financial side of their operations conservatively for a zero market price, regarding whatever added value they do get as an additional benefit rather than an essential ingredient of the operation.

The same question has been asked widely in the United States where the production of compost derived from sewage sludges, yard wastes and MSW has been increasing very rapidly over the last few years. Research has been undertaken by a number of responsible institutions, and the trends as predicted from the discoveries of the Battelle Institute of Columbus, Ohio, commissioned by The Composting Council in Washington, DC are indicated below on Tables 5.4 and 5.5.

Broadly speaking, the conclusion is "No problem". Among nine identified market sections, one simple industry, tree farming (silviculture), could consume more than the total projected output of all US composting operations presently active or at an advanced stage of planning. And that sector is calculated to represent just 10% of the market for composts. The Battelle report is clearly a leading indicator, and is quoted widely in trade journals such as BioCycle and Resource Recycling, as well as the Council's own inhouse publication.[57] [58]

"Practical potential applications for compost were found to be an order of magnitude greater than the amount of compost that can likely be produced. While approximately 1,000 million cubic yards (500 million tons) of compost could be used annually within a radius of 50 miles of urban centres (Tables 5.4), only about 100 million cubic yards (50 million tons) of compost would be produced if appropriate wastes were converted to compost (Table 5.5). Of this potential production of 100 million cubic yards of compost, only about 24 million cubic yards per year is estimated to be currently produced."[59]

The Institute for Local Self-Reliance recently studied 17 community programs in the United States in which recycling and composting had achieved more than 40% waste reduction. None of them apparently suffers from over supply.[60]

Table 5.4 POTENTIAL DEMAND SUMMARY

Application Segment	Potential Demand for Compost (Million cu yd)	Current Market Penetration (Percent)
Landscapers	2.0	<20
Delivered Topsoil	3.7	<5
Bagged/Retail	8.0	80
Landfill Final Cover	0.6	<5
Surface Mine Reclamation	0.2	<5
Container Nurseries	0.9	<50
Field Nurseries	4.0	<1
Sold Production	20	<1
Silviculture	104	<1
Agriculture	895	<1
TOTAL POTENTIAL	*1,040*	*<2*

Source: Battelle, 1992

Table 5.5 ***POTENTIAL SUPPLY SUMMARY***

Compost Source	Potential (Million cu yd)	Current (Million cu yd)
MSW	60	2
Sewage Sludge	6	<4
Horticultural Waste	30	10
Agricultural Waste	6	<0.6
TOTAL POTENTIAL	*102*	*17*

Source: Battelle, 1992

In simple numbers, Alberta has approximately 1% of the population of the United States, so that one might expect to be able to divide both the supply and demand numbers by 100 and come up with some indication of the likely figures for the province. More realistically, we can recognize three distinct market sectors in which the potential market in Alberta is proportionally larger than United States averages, those of:

- bagged/retail demand, on account of our short growing season and consequent reliance on the nursery industries,
- surface mine reclamation, on account of the major operations in the Wabamun and Forestberg areas, and
- silviculture, on account of the relatively large part that timber/wood production plays in our provincial economy.

Only one of these is judged by Battelle to be anywhere near capacity in the United States (retail sales, at about 80%), and we have a long way to go to catch up on their production before we can expect that degree of market penetration. The others still represent huge undeveloped markets which, a number of writers have noted, will accept lower grades of compost than the bagged/retail consumers without any detrimental effects.[61] Marketing studies conducted in 1990 by CMG related to the possible output from a MSW composting plant that was planned to be part of the proposed Aurum Integrated Waste Management Facility of the City of Edmonton showed a similar surplus of demand oversupply.[62]

5.3.6 Individual and Corporate Concerns

When all the matters of principle and of organization are addressed, there still remains the free-will of individuals or pressure groups who either wish to promote composting or to prevent a composting plant being built "in their backyard".

Among the former are many individual members of such established groups as REAP, the promoters of Resource Efficient Agricultural Production, whose journal ***Sustainable Farming*** now keeps its members abreast of developments in composting at McGill University and the Centre de dèveloppement d'agrobiologic du Quèbec.[63] At least one of the major pulp-mills and wood-products companies in Alberta is actively exploring composting as a more beneficial and economical way of disposing of its wood wastes and sludges.[64] A number of Alberta municipalities are now composting yard wastes, grass and leaves[65] and the Federal Correction Services expect soon to have a demonstration composting operation established at Bowden Institution to match that at nearby Olds College. The ability of compost to regenerate marginal soil is being exploited by a major public utility now mining coal by open cast methods, and the same virtues would appear to commend compost to the Prairie Lands Rehabilitation Unit. All these favourable initiatives could be used as models, encouraging others to follow their example and learn from their experience.

There are also negative perceptions of composting. Unpleasant odours from a new plant in Portland, Oregon, constructed to a very reliable pattern of which perhaps hundreds of other installations are working well elsewhere, have caused it to be closed indefinitely. Despite all that has been published on the subject, there are those who continue to view a waste composting plant as no more than an extension of the old "dump", and object to it on principle.[66] Care must be taken in the public process of approving each proposal to win over the support of those who have opposing viewpoints, particularly until composting becomes so well established that opposition born of ignorance is overcome by experience.[67] Until such time as there are enough demonstrable successes of composting in Alberta to promote this wider acceptance, it would be well to note the lobbying pressure of ultra-conservatives in the United States. The Agricultural Composting Association there is campaigning for stricter rules to control the use on farm land of compost made from anything other than organic wastes generated on the farm, to preserve the integrity of the farm soil base.[68]

5.3.7 Public Participation

There is a noticeable trend within the schools to demonstrate composting, along with other waste reduction methods, through small-scale worm composting boxes that can be adopted by a class. The popularity of Master Composting Classes in many municipalities testifies to the enthusiasm with which most communities are prepared to "give it a go", at least on the domestic scale. Vancouver has constructed demonstration gardens where composting can be seen alongside the results of growing things in the compost produced. The City of Edmonton and Alberta Agriculture have cooperated to mount a composting display

area in the grounds of the J G O'Donoghue Building. In this and numerous other ways evidence is mounting that public participation will nurture the provincial initiative in composting rather than reject it, the more so as the benefits of composting become more widely known through education and experience.

There is a growing awareness that, among other nations practising intensive agriculture with the help of inorganic fertilizers, Canada has been effectively "mining organics" from its arable land for years. The level of fertility in the soil is often as much as 25% lower than it was in 1950.[69] This process cannot go on indefinitely, as the dustbowls of Texas and the American mid-west testify. The widespread acceptance of the principles of sustainability propounded by the Bruntland Commission[70] would appear to indicate that the public has become aware of the danger of doing nothing.

5.3.8 Views of Local Alberta Practitioners

A composting workshop was organized at Olds College in July 1993 as an adjunct to this study. Representatives were invited from a cross section of rural and urban communities which, where possible, represented the "model communities" on which the waste composition studies were based. Active composters and others known to be involved in plans for composting were also invited. Forty delegates attended, providing a workable representation of the Alberta community.

The purpose of this two day workshop was to develop a supplemental data base for this study and to serve as a forum for exchanging ideas and concerns regarding opportunities and constraints associated with composting programs.

Workshop participants were organized into discussion groups according to the size of community represented. Care was taken to typify the generator models utilized for the study (*i.e.*, Large City, Small City).

Complete results of the workshop are presented in Appendix 4 of the Technical Appendices, a supplement to this study.

The following summarizes the key findings of the workshop:

1. It was unanimous among all participants, no matter what size of community they came from, that composting was worthy of strong consideration as a component of most waste management systems.
2. The results as presented, indicate that smaller communities experimented the most with different composting methods, including backyard composting, static pile and windrows.
3. Larger cities were involved in larger scale applications and indicated a higher degree of sophistication. Practitioners at this level were quite knowledgeable about composting methods but were interested in more technical data and advanced technologies. Practitioners from small communities were more interested in learning the basics and seeking simple ways of getting their respective politicians and publics on board.
4. All participants shared a unanimous concern that more could be accomplished through composting if the public and politicians, etc. were better educated about its benefits and techniques.

   In addition, participants felt more could be accomplished from government at both the provincial and local levels in terms of setting regulatory guidelines, standards and providing leadership support.
5. While a wide range of end users of compost materials were identified (e.g., farmers, landscapers, parks and recreation departments), there remains some concern that there is no overall, consistent, market for compost. More use could be achieved if people were made aware of the benefits of using composted materials within their own operations.
6. Finally, many of the participants, particularly from the smaller centres and towns, indicated that there is a growing opportunity for forming partnerships between public and private sector interests in initiating composting programs as part of their overall recycling activities.

The workshop confirmed that composting is an important component within the overall waste management industry and that, with proper public awareness and support, an understanding of community objectives and proper planning, an appropriate mix of composting options can be successfully undertaken.

In this section composting is considered at a number of organizational levels corresponding with the community models set up in Section 4.2, and in relation to programs of waste management needed to make it viable. Very broad generalities are recognized in the approximate capacity of different composting methods, in the capital requirements and the operating costs of each. The categories are not rigid, and the examples given are by no means exhaustive.

6.1 Levels of Composting Operation

There are three essential levels of composting activity which apply across the province:

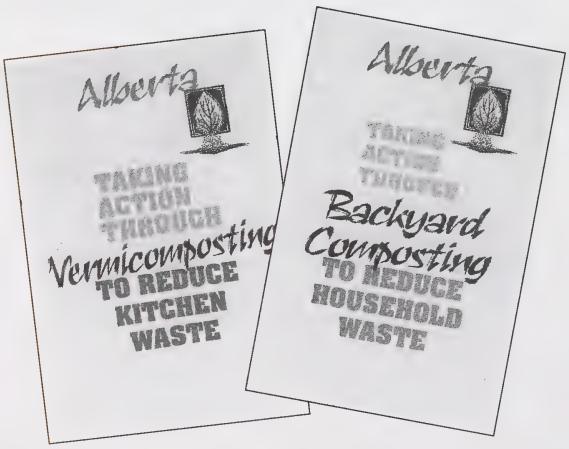
1. Composting at home;
2. Institutional composting by a commercial organization, a farm or a closed community such as a hospital or prison; and
3. Community composting, which may be on a variety of scales but necessitates organization and transportation at a higher level than an operation confined to materials that are collected and processed on a single site.

6.2 Home Composting

Home composting is generally applicable to two sets of organic material, yard wastes and kitchen wastes, although individual circumstances may reduce these to just the kitchen wastes if the home has no substantial garden space, as is the situation for many apartment dwellers.

Several Alberta cities and municipalities have already organized Master Composter Classes to promote backyard composting, and numerous leaflets and phone-in services are now available to assist the new composter. Alberta Environmental Protection also publishes ***"Taking Action Through Backyard Composting"*** and ***"Taking Action Through Vermicomposting"***[71], providing many helpful hints, and publicizes its "Recycle Info Line" service to handle enquiries.

Figure 4 - Sample Home Composting Brochures



These programs are to a large degree dependent on the sustained enthusiasm of the individual householder. In many instances they have been given a "kick-start" by the municipality making composting bins of one sort or another available at a subsidized price. Kitchener, Ontario and the Alberta communities of Fort Saskatchewan, County of Strathcona, and Leduc have done this. Vancouver and Victoria have established display areas where demonstrations of composting techniques are given, and the benefits are shown in cultivation patches.[72] Edmonton has a demonstration site and Olds College is developing a similar area.

In the Alberta climate, ***worm composting*** is largely restricted to indoors, and is thus ideally suited to individual homes (houses or apartments) where only food wastes will be composted.[73] Worms will consume virtually any organic scraps from the kitchen along with shredded paper. They need warmth, and they need to be contained. Many municipalities have promotional literature to guide the composter. Home-build plans and worms suitable for composting are widely available, and a considerable variety of kit-form or ready-made bins are on the market. A start-up kit composed of composting box and worms can cost about $75. With enthusiastic organization such a scheme may be extended to many homes, as was proposed for the University Residences in the University of Calgary[74], and can in the summer months operate out-doors. But it is far more usual to promote some kind of bin or drum composting if the larger volumes of material coming from a yard are to be included.

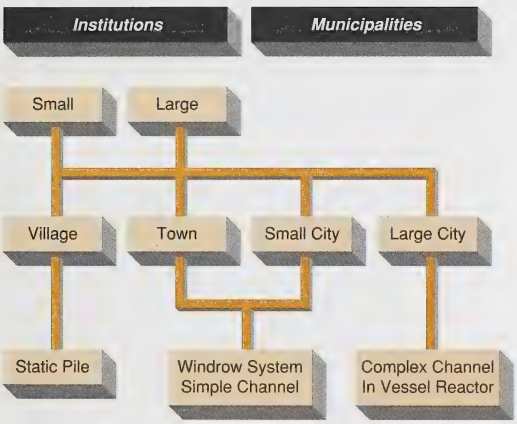
A garden or yard will produce more greenery than an indoor worm composter will cope with. The range of equipment suitable for ***yard waste composting*** includes aerobic composters and anaerobic digesters, and can be made or purchased. Typical static composting bins, built usually of cedar but some using the "superwood" material made from recycled plastics, are widely available at prices ranging from $25 - $125. More efficient tumbling varieties cost from $100 - $200. The digesters, usually of black plastic to absorb as much heat as possible, fall into the $50 - $100 range. All are sized to deal with the yard waste from a typical urban lot, and will be smaller than what is needed for an acreage.

6.3 Institutional Composting

With increasing size of the property and more inhabitants, the bulk of compostable materials increases and with it the diversity of organics that can be composted; the simple backyard bin becomes inadequate. A range of options is open, depending on the size of the institution undertaking the compost operation, broadly encompassing various forms of static pile, windrow or simple channel composting. At this scale the degree of organization required is still within

the individual institution, whether it be a farm operation such as that conducted by Mr. John Sadler in Redcliffe, a health care facility such as the Grace Hospital in Calgary or a Correctional Institute such as CSC Bowden. In terms of capacity and organization for composting, large institutions merge into small municipalities as shown in Figure 5.

Figure 5 - Capacity and Organization for Composting



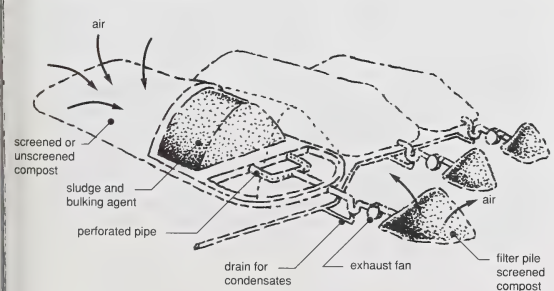
6.3.1 Static Pile Composting

In its simplest form, the Static Pile is a simple method of open-air stock piling of compostable materials with occasional turning for aeration. The piles can accommodate quantities of kitchen waste and soiled paper, provided it is shredded beforehand. In the United States this method is widely used for composting sewage sludge. The piles should be constructed on some sort of waterproofing pad, of rolled clay, concrete or asphalt, and have provision for the collection of run-off water to protect the environment from contamination by leachates.

Such piles are greatly improved by inclusion of an aeration system, either in the form of perforated pipes that provided natural circulation of air by the convective power of the heat generated, or powered by some form of blower.

Figure 6 - Aerated Static Pile Process

(Source: United States EPA Process Design Manual for Sludge Treatment and Disposal, page 12-22.)

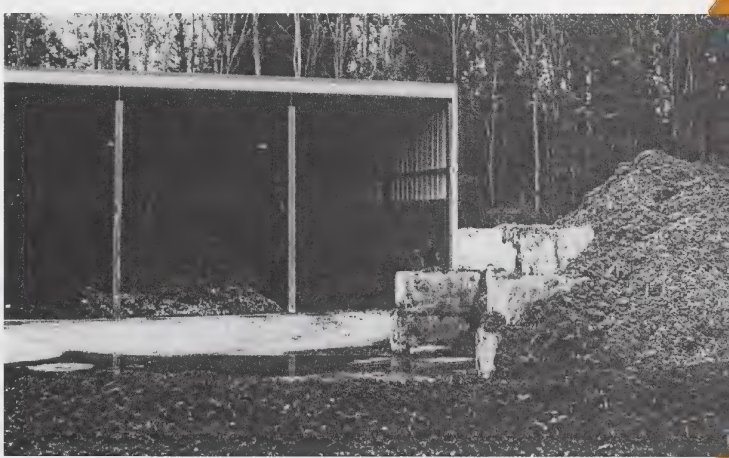


This sort of composting is definitely superior to leaving grass clippings, brush and vegetation or farmyard manure in untended piles directly on the ground, and can be suitably undertaken by almost any farm, college, hospital, golf course or similar yard waste generator.

Piles are also formed in simple open-fronted structures like a typical farm implement shed, with air fans mounted on a back wall and air distribution either through pierced piping or some form of under-floor duct for improved performance and control. The addition of quantities of highly nitrogenous wastes from a stock yard or a small water treatment plant greatly assist the composting process. Meats and other food items likely to attract predators should not be included.

Construction costs for an aerated static pile with a capacity of 500 tonnes/year can range from about $50,000 to $100,000, depending on the degree of sophistication, and on-site operational costs are typically quoted in the range of $25 - $45 per tonne.

Figure 7 - Aerated Static Pile Composting



The principal advantages of this method include:

- the least capital investment for equipment
- comparatively small area required for the operation
- lower level of technical and operational skill requirements

The principal disadvantages include:

- high potential for offensive odours, if not well aerated
- long process retention times to produce a stabilized compost
- lower quality end product, compared with more sophisticated systems
- large land area requirements if more than modest quantities of organics are processed

At this small scale there are a number of innovations coming onto the market, such as the unit tunnel composter recently installed at the Ontario Science Centre in Toronto.[75] Not enough is yet known of its performance to place it adequately in a hierarchy of sustainable options.

6.3.2 Windrow Composting

This method takes its name from the traditional method of curing hay by raking and turning over the hay in long parallel rows called windrows. Similarly, the compost windrow is a triangle or trapezoid shaped row of compostable materials, which is periodically turned for mixing, aeration and moisture control by front-end loaders or special equipment designed for the purpose. The more complex systems incorporate some type of air diffusion bed or a network of perforated pipes beneath the long rows of compostable materials, to facilitate controlled aeration in the intervals between turning.

Even though the materials being composted may be largely naturally occurring wastes such as farmyard manures or tree clippings, their concentration in a small area can give rise to a potential overload of nitrogen and other elements in the area occupied by the composting operation. Concern for environmental protection may require some from of impervious hard surface to be laid underneath the windrows, and provision made to collect liquid that percolates down through the composting biomass (leachate).

Figure 8 - Scott's Composting Facility, Ontario.
(Photo courtesy of Canadian Portland Cement Association)

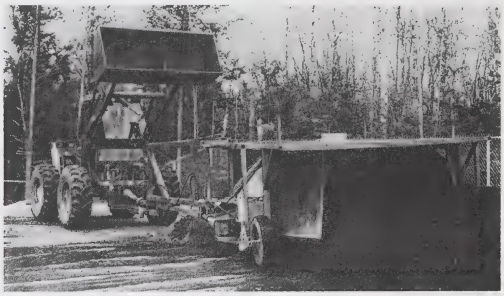
The operation depicted, by private Ontario composters, shows clearly the impervious concrete pad and a leachate collection pond[76]. Although they are conducted in the open, these and numbers of similar Canadian operations are reported to continue throughout the cold winter months, relying on the heat generated by the compost process itself to keep them from freezing and remain microbially active.

Windrow composting has been operated successfully for large volumes of yard wastes and selected kitchen wastes, for farm-yard manures and for a variety of sludges provided a "bulking agent" is added to provide adequate passage for air through the biomass.

Windrow composting can deal with a wide variety of organic wastes at almost any operating scale.* In practical terms, open-air windrow composting has been successfully operated in the range of 5 tonnes per day to 100 tonnes per day (1,000 tonnes/years - 25,000 tonnes/year), while large mechanized windrow systems employing extensive front-end preparation of the material prior to composting go up to 100,000 tonnes/year and more.

Simple open-air windrows will require a front-end loader as the minimum equipment for building and turning. More specialized turning equipment can range from a unit towed beside a tractor and using its Power Take Off (PTO) for rotor-power costing from $10,000 to $25,000, to large purpose-built self-propelled units that typically cost $75,000 to $125,000. Suitable models in both categories are manufactured in Canada and the USA. Therefore depending on its degree of mechanization, an operation of about 5,000 tonnes/year capacity could cost some $250,000 to $500,000 to set up, and typically about $30/tonne - $40/tonne to operate.

Figure 9 - Power Take-off Windrow Turner



The principal advantages of the windrow method include:

- moderate installation cost
- shorter process retention time than non-aerated systems
- slightly better quality end product than the static pile systems (the quality of the end product can be enhanced by covering the work area over the windrows, but the associated costs can be excessive)

*Until 1988, a large portion of Holland's urban MSW was composted in a huge central windrow system, the VAM process. Less ambitious in scale, the LEEDS process has been tested for open windrowing of MSW in developing countries. These and other references to particular developments and proprietary equipment are solely for purposes of illustration, and imply no endorsement or recommendation of one process rather than any other.

Figure 10 - Self-propelled Windrow Turner

The principal disadvantages of the method include:

- relatively large land area requirements
- operating costs can be higher than Static Pile
- lower compost quality than enclosed systems
- higher odour potential than enclosed systems
- susceptibility to adverse weather conditions

Windrow composting with some kind of mechanical turning is already quite widely practiced in Canada. The Composting Council of Canada's 1993 survey lists 12 such operations in Alberta and the Yukon[77] alone and in other parts of Canada more than 80 such systems are in operation. Although most of these are actually municipal operations, for communities varying in size from 250 to 700,000, numbers of others operate at a smaller scale of organization. In this province, Grace Hospital in Calgary composts lawn clippings and Olds College composts manure. Windrow composting is planned for the farmyard wastes and other organics of Bowden Institution[78] and at least one private operator in the Edmonton municipal area plans to offer an organic waste recycling service to local supermarkets.

Some form of collection system must be provided within the community, often allied with a drop-off possibility for private carriers, to collect a sufficient quantity of material to make this operation viable.

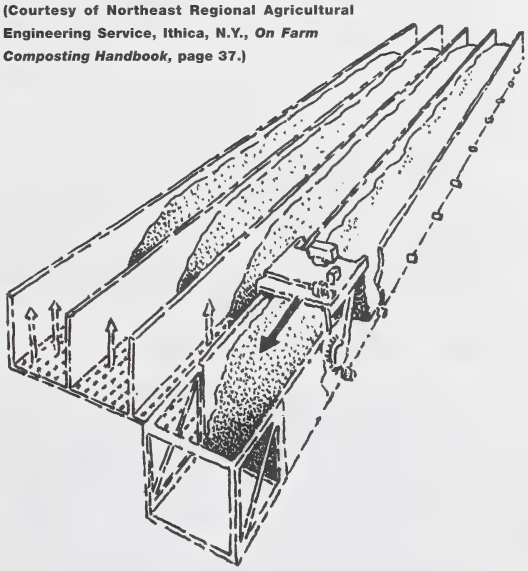
6.3.3 Enclosed Composting Systems

The more advanced composting systems developed in Europe and the United States now offer a wide variety of operation in which the composting process takes place within a channel, enclosed on both sides but open at the top, or in a fully enclosed structure or vessel. In some of these, known collectively as "tunnel reactors", the materials are either treated as a batch or moved progressively through the tunnel by the pressure of incoming new material. The Double T reactor developed in Alberta typifies this technology. In the majority of open or enclosed systems the biomass is frequently mixed, transported and aerated by mechanical means in an automatically programmed process. Both simple and complex systems use forced aeration to provide oxygen for relatively odour-free aerobic decomposition of the organic materials. They are described in more detail below, with some illustrative examples of each technology. There is a wide variety of systems and equipment available on the market, and would-be composters are encouraged to become familiar with the relative merits of a number before making a selection for their own application.

6.3.4 Channel Composting

In the simple system frequently referred to as the *open channel* system, the biomass is contained between parallel vertical walls, with the compostable materials loaded at one end and the finished product (compost) discharged from the other.

Figure 11 - Channel Composting System
(Courtesy of Northeast Regional Agricultural Engineering Service, Ithica, N.Y., *On Farm Composting Handbook*, page 37.)



The compostable material is transported through the channel by a specially developed turning machine. A turning machine, which either runs along the top of the channel walls or straddles them, agitates the biomass periodically, providing for constant re-mixing and adjusting of the moisture content. The channels vary in width from about 2 metres to an entire building span, depending on the type of composting machine used. The depth of the composting bed is limited to a maximum of about 2 metres to ensure effective aeration throughout the contained biomass.

Small, single channel systems are operating successfully on farms in Ontario, composting basically farm-yard manure but with the capacity to handle quantities of kitchen

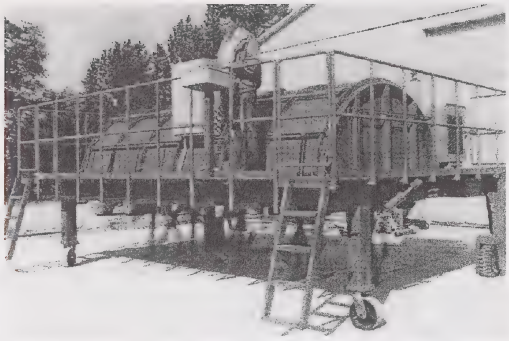


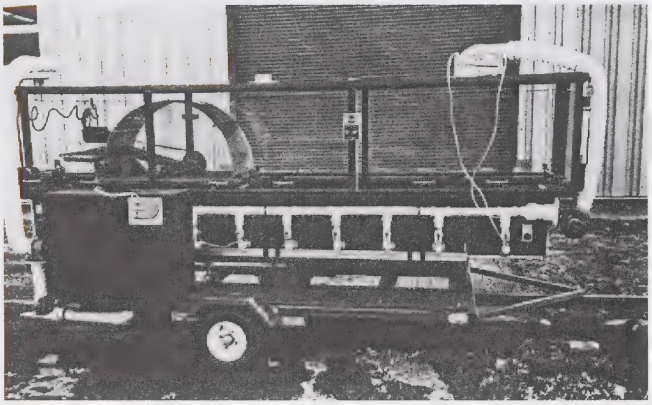
Figure 12 - In-Vessel Travelling Compost Turner
(Photo Courtesy of L.H. Resource Management Inc., Walton Ontario.)

wastes, yard wastes and other mixed organics. Two or three channels can be built side by side, and serviced by the same turning machine.

Professor Jack Pos at the University of Guelph developed a composting channel and travelling turner for the manures at the Department of Animal Husbandry in the University. Half a dozen of these are working on farms in the northern United States, at a milling plant in Ontario and at the stockyards in Yellowknife.

Special versions of such channel systems have been developed in universities and research institutes, to meet specific needs. The University of West Virginia has a mobile model which can be taken to any site, to carry out trials on the organics available under local ambient conditions.[79] A

Figure 13 - Mobile Composting Reactor



similar channel system was developed for the Campbell River Research Farm of the University of British Columbia to deal with morts and other fisheries wastes in an environmentally responsible manner. In the prototype version the paddle-wheel agitator could be turned and traversed by hand.[80]

Typically, an open channel composting system with a capacity of 30 - 50 tonnes per day may have a capital cost in the region of $1.5 million - $2.5 million, inclusive of site engineering, buildings and machinery. Operating costs may well be between $35 per tonne and $60 per tonne, depending on site organization and other operational variables.

The principal advantages of this process approach are:

- much shorter process time than other composting methods, of the order of 20-30 days for the biological process and curing, thereby reducing the overall size of the equipment and composting space required
- good process control, especially if a biofilter is used
- high quality and consistent end product
- good odour control
- low visual impact, since the plant is in an industrial building

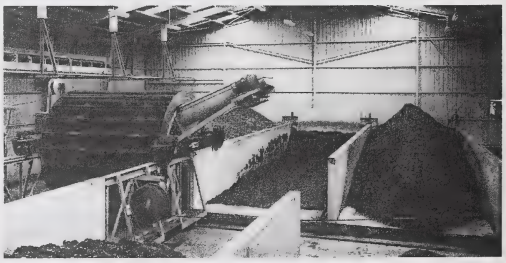
The principal disadvantages, on the other hand, are:

- higher construction and operation costs than windrow method
- higher level of management skills required, relative to windrow system

6.3.5 Complex Channel

The greater the quantity of material to be composted and the more diverse its content, the more complex is the equipment needed to prepare the biomass for effective composting. Typically, these systems are installed by municipalities with 100 tonnes/day or more of organic waste to deal with, and will usually have some form of pre-treatment built into the front end. The operational range of complex channel systems is generally from some 25,000 tonnes to 250,000 tonnes/year.

Figure 14 - Channel Composting System
(Photo courtesy and Property of OTVD. The Siloda Wheel is a patented Property of OTVD, New York, N.Y.)

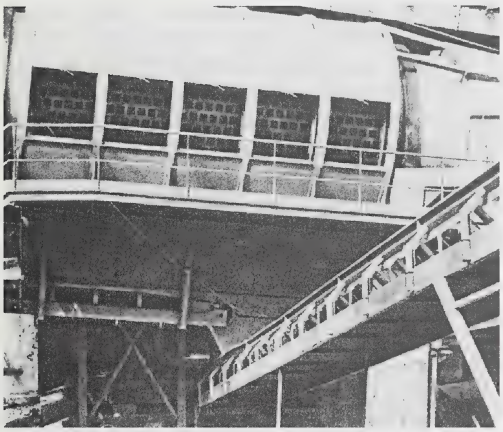


Two such systems are illustrated, each built and operated by private companies as a municipal service. A plant with 50,000 tonnes per year capacity, able to receive a broad variety of organics and refine it at several stages in the

process to produce a fine quality of compost, could well require $15 - $30 million in capital expenditure.

At this level of operation, the running costs are generally reflected in a *"tipping-fee"* for material received at the gate, which reflects both the actual operational cost and the value to the community of diverting the waste from landfill. Charges are typically in the range of $60 - $90 per tonne, including the cost of disposal of residual material that cannot be composted.

Figure 15 - Channel Composting System



6.3.6 In-Vessel Composting

With the increased capital investment needed for an in-vessel system comes an increased sophistication in the collection and transportation needed to bring in sufficient materials to make the operation worthwhile. The low end of capacity of viable channel systems is about 50 tonnes per day, 150 tonnes per day being a more typical low end for economy while the more complex drum reactors built by large European manufacturers can fully process up to 3,000 tonnes/day[81].

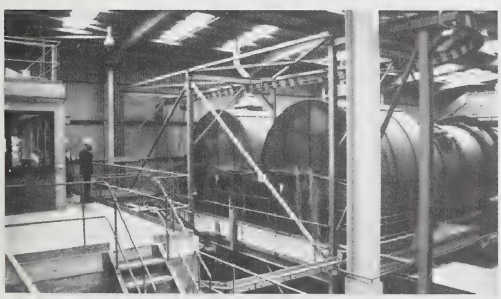
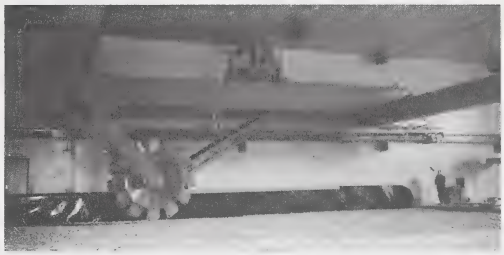


Figure 16 - South Manchester Refuse Treatment Plant (include tunnel composter)
(Photo courtesy of Resource System Corporation, Portland, Oregon.)

Figure 17 - In-Vessel Compost Turner
(Photo courtesy of Buhler (Canada) Inc., Markham Ontario.)



Large scale municipal composting operations generally use one of the complex channel or windrow finishing systems, coupled with intensive pre-treatment and initial compost preparation in a dedicated enclosed vessel. The designs vary widely, and three are illustrated here to exemplify the complexity and variety of the systems. The larger operations usually employ some duplication of modular units to generate the very high capacities. Costs are directly related to size, and are typically of the order of $30,000 to $35,000 per tonne per year of capacity.

Operating costs are generally one part of the tipping fee received for material diverted from the landfill, and usually fall in the same range as before, $60 - $85 per tonne.

Perhaps more typical of a likely Canadian municipal operation is that currently under development in the Municipality of Guelph, with a planned capacity of about 40,000 tonnes per year. In order to maximize the quality of the end product, the city is instituting a "wet/dry" collection system which will separate the compostable organics from other recyclables in the waste stream at source.[82] [83] This is fairly typical of current practice in Europe, where composting of municipal wastes is somewhat in advance of most North American practice, and is increasingly popular in Canadian municipalities where any form of municipal solid waste composting is contemplated.[84]

6.3.7 Other Notable Composting Systems and Programs

The co-composting of solid wastes and sludges from urban sewage treatment has been briefly mentioned above. There are possibilities for composting the sludge on its own, in facilities using several of the processes described or some combination of them. The pictures at 6.3.1, for instance, are of a static pile process for sewage sludge and of a sludge composting facility in Quebec, where the sludge and wood chips are mixed together in a windrow by a special windrow-turning machine, then transported to the shed for aeration over an extended period in covered piles.[85] The facility is located close to the sewage works, so smells generated by the process are indistinguishable from those of the nearby plant. The Environmental Protection Agency (EPA) devoted a great deal of time some years back to developing the

"Beltsville" process for composting sludges in aerated static piles,[86] [87] while other cities such as Newberg, Oregon have used a tunnel reactor for the same purpose.

Of special interest, mushroom growing is a sophisticated technology in itself and the manufacture of mushroom compost implies mixing materials for growing a specific organism after eliminating all others by sterilization. Alberta has a well-known manufacturer of specialized equipment for this purpose, in which control of air flow and odours is highly organized.[88] Spent mushroom compost, what is left after the mushroom production, can be used on land but it is not necessarily fully mature because biomaturation was not the object of the composting process.

Invented in British Columbia and first demonstrated as a full scale working installation at the Ontario Sciences Centre is the totally enclosed tunnel composting reactor developed by Wright Environmental Inc. Batches of material for composting are fed in daily at one end and processes continuously as they travel towards the other end, where they are discharged for longer curing in a conventional way. The system can handle putrescible organic waste, including meats, fish, dairy products, fruits and vegetables. Models can be built in a variety of sizes ranging in capacity from a few hundred kilograms to a number of tonnes per day.

Figure 18 - Mid-scale In-Vessel Composting System

In the Federal Correction Service, a policy of waste reduction to conform to the requirements of Canada's Green Plan has resulted in plans to compost the very considerable quantities of manure generated at each prison farm. The ease with which these organics can be composted provides the prison an alternative disposal route for all other organic wastes which were previously landfilled.[89] [90] In Ontario, the parallel scheme at Kingston Penitentiary has been extended to other institutions of the Federal Government, such as the kitchen wastes from the nearby Staff College. Similarly, the capacity of the farm waste composting program for the Prince Albert Institution in Saskatchewan is such that it is able to incorporate the organic wastes from the City of Prince Albert and, possibly, a large paper mill nearby.[91]

Environment Canada has recently provided financial support for the development of a fully contained composting bin with a capacity of about 3 tonnes/day. The prototype was first tried out at Powell River, BC, and a more advanced design is now installed at the Ontario Science Centre in Toronto.

Figure 19 - Mobile Compost Unit
(Courtesy of AG-RENU, Kettering, Ohio, U.S.A.)

Of special interest to smaller resort communities is the experience of Frost Valley YMCA in northern New York State referred to in Section 5.3.4.[92] The food wastes from campers at the resort are composted in bins in a dedicated but unheated building, and used to grow vegetables in demonstration plots which show the advantages of such environmentally responsible waste management. An interesting program developed in the United States for smaller communities is based on the concept of the truck-mounted concrete mixer. Numbers of these trucks, each capable of handling more or less 2 tonnes of material, mix and turn the biomass for the minimum period of 72 hours required for pasteurization,[93] before discharging the immature compost onto a pad for curing.[94]

It is not unusual for large garden centres to compost their own green wastes and use the product as a growing medium in their own industry.[95] Like the prison composting schemes noted earlier, this can provide the basis for a wider composting program to be developed as a commercial service, as has been done by Webbs Family Farms in New Hampshire, in the northeast United States, ***The Answer Garden Centre*** in the Fraser Valley of BC[96], by the Sadler operation in Redcliffe referred to above, and by Mr. Roger Wood of Nampa Farms near Boise, Idaho[97]. While by no means exhaustive of private and corporate initiatives, these may serve as illustrations of the wide possibilities open to public and private sector composters throughout Alberta.

6.4 The Most Suitable Options

In practical terms, since the ***home composting*** options discussed in Section 6.2 apply to every residence and institution in the province, they do not figure further in the evaluation which follows. Implementation is largely a matter of individual or local collective enthusiasm, within the constraints which may be imposed by propriety in given situations such as the need to respect regulations enforced by Parks Canada within their area of jurisdiction[98], and may be encouraged by any of the stratagems discussed in Section 7 below.

Within the broad range of community or ***institutional composting***, the suitability of the various process options described within the previous section depends on a number of variables, including, but not limited to:

- availability of feedstock
- technological compatibility
- waste diversion potential
- potential for commercial development
- environmental and health risk
- relative annual costs
- program performance
- public acceptability

As has been demonstrated in the description of each option, parameters such as quantity of feedstock available and the capability of a given community to undertake the levels of capital and operational commitment broadly outlined there have a major impact on the selection of the best, or even of an appropriate, solution.

6.4.1 The Effect of Feedstock Supply and Collection

Feedstock is defined by quantity and quality. The criterion of frugality places an imperative on selection of the least expensive option, other things being equal - though capital expense and operational expense both have to be considered. The quantities of feedstock that guide the selection of the various options are indicated in Table 6.1 below, where it is suggested that a minimum threshold quantity of materials is needed to best utilize the inherent benefits of each option. There are also upper limits to the practical nature of simple systems, beyond which a more capital-intensive option is generally more appropriate.

It must be recognized that these categories of process selection are by no means hard and fast or absolute; there is always some room for manoeuvre, compromise and invention. For instance, while the "*cement mixer*" operation depicted in Section 6.3.7 above is clearly best suited to small applications of a tonne or so per day, its proponents have prepared layout sketches showing up to 64 units ranged side by side, with a combined capacity of 50 tonnes/day or more.[99] It is not known if such a facility has ever been built or operated successfully.

As far as quality of feedstock is concerned, all forms of *MSW* have been successfully windrow composted in other countries and other climates.[100] Commingled wastes, industrial and waste-water sludges, yard wastes and food wastes, manures and even dead fish or animal carcasses are composted in windrows with an appropriately balanced material mix.[101]

If the supply of feedstock is largely seasonal, such as yardwastes throughout Alberta, there will be no restriction on windrowing other than the upper limit at which a site becomes unwieldy. Simple aerated static piles, protected only by an agricultural implement shed, also operate readily in the range of temperature conditions experienced during the spring to fall seasons, when yardwaste is a very significant part of the total MSW collected. The *Beltsville* static pile system was developed for sewage sludge composting in the United States.[102] If the supply is fairly constant year-round, the need to continue to deal with putrescible materials such as food wastes in timely fashion, as required by considerations of Public Health,[103] may well place pressure on the selection of a system that is housed in a totally enclosed building, which at once makes a channel or in-vessel composting system more appropriate.

Lastly, it will be observed that if significant quantities of farmyard wastes *(FYW)* can be brought into the composting process from the surrounding community, from a racetrack, a slaughterhouse or a stockyard, operation becomes greatly simplified by the inherently good *C:N* ratio of the material. *FYW* composting is able to absorb at least an equal quantity of other municipal organic wastes and still remain a largely agricultural operation, for which simple channel composting was developed and is ideally suited.[104]

6.4.2 Technological Compatibility

All composting produces some odours, and faulty or mismanaged composting produces unpleasant ones. Any operation can experience temporary glitches, and it is prudent to match the degree of technological sophistication to the location of the composting facility. Open windrow or aerated static pile operations for *MSW*, sited at an existing landfill, are likely to blend into the background without being noticed. Sewage sludge composting, by whatever means, is an activity compatible with the operation and location of most sewage treatment facilities. Locating a composting facility on the same site would also, in all likelihood, reduce the time frame for approval.

As quantities increase, the area of land needed for windrow composting will increase in almost linear ratio. Site preparation for adequate protection of the soil and groundwater can become complex and expensive, as impervious barriers and leachate collection systems are constructed and monitoring wells installed. With an increased diversity of materials to be handled, a more mechanically complex system reduces the size of the site required, the time taken to produce an acceptable compost, the susceptibility to climate and weather conditions and, generally, the staffing needs, although more highly qualified staff will be needed for management, operation and maintenance. Thus while windrow and static pile composting needs mainly agricultural equipment, aided by a dedicated windrow turner, in-vessel systems use much more specifically designed equipment and need staff who understand it.

6.4.3 Waste Diversion Potential

Provided the feedstock is seasonal, or suitable stockpiling presents no great difficulty in cold seasons, all the systems and processes discussed can divert their effective capacity range of materials from disposal by landfilling or incineration. The diversion, as discussed in Section 4.3, ranges from 40% to 70% in any given community. The

Table 6.1 Compatibility of Compost System Options

Composting Method	Thresholds Tonnes/yr	Cost Implications		Model 1 Small Village	Model 2 Town / Non Farm	Model 3 Town / Farm	Model 4 Small City	Model 5 Large City	Model 6 Resort	Model Integrated
		Capital	Operational							
Static Pile	50 to 1,500	$50,000 to $100,000	$25 / t to $45 / t	Y Y	Y Y	Y Y	Y Y	N N	Y Y	N N
Windrow	1,000 to 25,000	$10,000 to $500,000	$30 / t to $50 / t	Y ?	Y Y	Y Y	Y Y	? Y	Y Y	? Y
Simple Channel	5,000 to 100,000	$750,000 to $1.5 mil	$35 / t to $65 / t	? ?	? Y	Y Y	? Y	? Y	Y Y	? Y
Complex Channel	25,000 to 250,000	$5 mil to $30 mil	$60 / t to $90 / t	N N	N N	? ?	Y Y	Y Y	? ?	Y Y
In Vessel	50,000 + upwards	$15 mil upwards	$65 / t to $100 / t	N N	N N	N N	? ?	Y Y	N N	Y Y

Criteria: Technical Compatibility - Top Line

No: insufficient base volumes to meet threshold

Yes: sufficient base volumes to meet threshold

Affordability - Bottom Line

No: insufficient local financial resources to support and sustain necessary technology

Yes: sufficient financial resources to support and sustain necessary technology

? no clear indication of an obvious choice

essential element needed to make composting work may well be *another* waste material, so that the matching of wastes for an optimum ***C:N*** balance or moisture content can dispose of wastes from more than one source, and so become a "win-win" situation for all concerned. Tentative agreement has been reached with the Waste Materials Exchange operated by the Alberta Research Council (and by equivalent public bodies elsewhere in Canada and the United States) to list compostable wastes in a special category of their inventory system[105], to facilitate such matches.

As noted below, much work remains to be done to maximize the quantities of organic waste material from farms and feedlots that could be composted. Composting manures is a more responsible way of using them than spreading them on the land untreated, in terms of overall environmental impact.[106] Some re-education will be necessary, since the practice of manure spreading on farm land is so firmly established. The same is true of sludge application to farm land, which is strongly controlled by regulation to prevent overloading the soil with heavy metals. If the sludge is composted, the potentially harmful effects of these metals are greatly reduced (see 5.2.2).

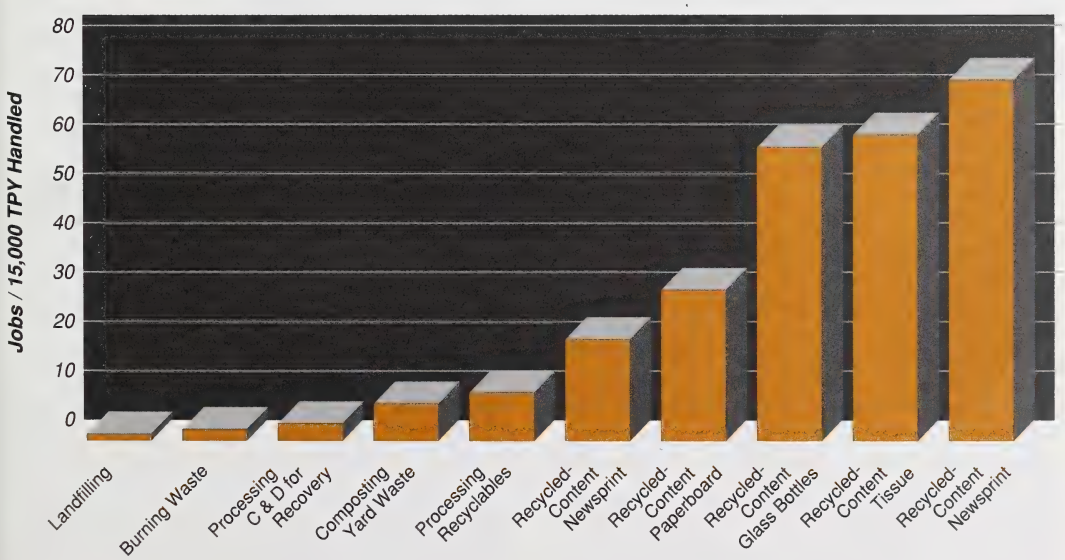
In general terms, the more complex processes such as hybrid channel or in-vessel systems have the capability and capacity to divert much larger quantities of materials that are comparatively difficult to handle. They are built with front-end processing equipment to prepare the materials for ideal composting conditions and the sophistication of their materials handling, monitoring and control functions gives them better control of the composting process than is possible with a comparatively simple system.

6.4.4 Economic Development Opportunities

Materials recovery creates more viable jobs than do disposal options. For example, in the United States, for every 15,000 tons of solid waste recycled in a year, nine jobs are created preparing materials to meet end user specifications. For the same amount of yard waste composted a year, seven jobs are created. In contrast, only two jobs are created for every 15,000 tons of waste incinerated a year and only one job for the same amount of waste landfilled a year (see Figure 20).

For larger communities, recycling and composting can offer another economic benefit: the attraction of new industry. Indeed, big cities and urbanized areas should make recycling and composting an integral part of their local economic development programs. A city such as Edmonton has developed sizeable MRFs to serve the Blue Box program, Paper Chase and other recycling programs dealing with plastics and metals, and a central exchange for recycled building materials. It has been calculated that a city of this size, by diverting 43% of its waste, could generate sufficient discarded materials to supply up to 29 factories employing over 1,800 people and realizing overall sales of over $700 million a year.[107] Scaled down to smaller cities and towns, there is still an impressive potential for "second-order economics" of recycling, providing employment and generating revenue in the community. Our

Figure 20 - Job Creation At Different Waste Handling Facilities



ability to capture the maximum value from our solid waste will depend on our willingness to undertake complex financial and logistical processes needed to create successful business ventures.

Round table discussion at the Olds College workshop that formed an integral part of this study, summarized at 5.3.8 above, indicated that most of the smaller communities represented would expect to use virtually all of the compost they might produce in municipal public works of some kind. Despite this desire to "close the loop" in local waste management, it is noteworthy that a modest number of commercial composting operations are already in progress in Alberta as developments in the private sector, contributing to employment and to the economy.[108]

In larger communities, such as Calgary and Edmonton, there is greater potential for private sector development and a diversity of markets. This does not mean that there is only one direction for the choice of an appropriate process. One private developer who has obtained a permit to compost in the west of Edmonton plans a small operation of not more than 10 tonnes/day operating on the windrow principle, as a waste diversion service to the food marketing industry and a producer of commercial grade compost.[109] At the same time, a major utility corporation and a major transportation company in the province have tabled proposals for composting operations which, between them, could deal with the great majority of the City of Edmonton's solid organic wastes and some of the sewage sludges.[110] Both are private ventures, and will create new employment at several levels of the collection, sorting, treatment and distribution process.

Each process option, identified in Section 6.0 above, has potential to serve an appropriate level of composting activity if care is taken to match the several parameters discussed, and all together are not likely to oversupply or even meet the province's need for compost.[111]

An example of the application of all of the principles discussed above to a particular model community has been worked out in the context of a private sector development. Section 9 provides a theoretical study showing how an Alberta utility corporation could develop composting facilities in any of the communities represented by the model category "Town with Farm".

6.4.5 Environmental and Health Risks

The larger the composting operation, the more putrescible organic material is concentrated in one place. This increases the possible overload of the natural and human environment by a range of potentially harmful elements, such as windborne spores, nitrates and heavy metals. The more highly engineered systems have, by their nature, better built-in protection of the environment and of their workforce. Odour control, to take a single example, is better managed in a fully enclosed facility using sophisticated air handling and monitoring equipment than in an open windrow or static pile. Only the larger channel and in-vessel systems have these kinds of equipment as standard process elements.

At the same time it has to be noted that Olds College has found it possible to compost yardwastes and manures directly on the ground in open windrows, with no environmental protection structures or devices. Site monitoring systems that are in place show no harmful effects on the groundwater, due to careful site selection, and there is no recorded history of workers' health being put at risk.[112] These observations are fully compatible with the advice received as a result of the Edmonton Board of Health's study of composting, discussed in Section 5.3 in this Study.[113]

6.4.6 Performance of the Program

Properly managed composting operations are being pursued in Europe, the United States and other parts of Canada, many of them *for profit* operations, using all of the process options discussed. This suggests that there is probably a suitable program model that can be made to perform adequately in virtually any Alberta situation. Some programs will be narrowly defined, concerned only with the actual composting operation, while others will include collection and sorting of materials, transport and marketing of the compost produced. Some will show more ingenuity and novel development, to suit a particular set of operating conditions. The important step is to select an appropriate process, and this is largely a function of finding the right fit with the type and quantity of feedstock, location of the facility and the composter's ability to finance the operation.

6.4.7 Public Acceptability

The widespread application of the major processes discussed, their continued evolution, and the energy with which new developments are pursued in the public and private sector and as academic research,[114] testify to a broad general acceptance by a majority of the informed public. This acceptance is not only local acceptance of a local initiative. At least one of the major composting schemes under review by the Edmonton Capital Region Waste Management Commission in mid 1993 is to be located in a relatively small community remote from the source of its feedstock, and has received broad popular support at every level of the local community.[115] The quality of the finished compost will always have a bearing on how well it is received, but there is room for compost of more than one specification in Alberta. Oil well drilling site or coal mine reclamation, for instance, can well use a coarser compost than would be bought in an urban garden centre. Responsible management of the facility, which responds openly and rapidly to public concerns as they arise, would appear to carry far more weight as a criterion of public acceptance than the scale of the operation or the choice of process.

In order to give some guidance to decision makers at all levels of the administration on measures that may most effectively support sustainable composting, it is helpful to refer to programs that have been tried in other jurisdictions of Canada, in the United States and in Europe. From their often notable successes one may gain direction and, from a review of their inevitable few failures, our province can avoid some of the pitfalls.

7.1 Relation Between Economic and Political Initiatives

At the very outset it is worth recognizing that there is a close relationship between economic measures that may assist composting programs and the political process. Many programs that have been kick-started with funding from some level of government have faded out when the funding was phased out.[1] This is of no great service to *sustainability*. It will also be recognized that the impressive increase in recycling and composting programs all over North America in the last decade correlates closely with widespread waste reduction legislation passed by federal authorities, by provinces and by states. The decisions of the Canadian Council of Ministers of the Environment (CCME) and of the US EPA, the legislation of Ontario's Ministry of the Environment and Oregon's "Opportunity to Recycle Act", Minnesota's banning yardwaste from landfills and Alberta's Beverage Container legislation, all illustrate the political initiatives that have given the impetus to the growth in recycling and composting activity, and to releasing "carrot" funds to help it onto its feet.

Conversely, the adverse economic "sticks" of placing surcharges on the landfill costs of materials that can be diverted, as Edmonton has on corrugated cardboard (OCC), and of banning tires altogether, must also be supported by initiating legislation.

7.2 Programs Showing Substantial Diversion

A helpful review of 17 communities across the United States where substantial waste diversion of 40% and over is being sustained[118] shows clearly that composting is most viable, and thus most *sustainable* in the long run, when integrated into an overall recycling program. Their success appears to be independent of the size of the community and of geographical constraints. Examples are cited from Wilton, WI, one of the most aggressive States in terms of its legislation,[119] with a population of about 500, to east coast Woodbury, NJ with 10,500 residents and west coast Seattle, WA with 500,000 or so in the main city. The eight most noteworthy areas in which thoughtful action and legislation (with or without financial incentives) can be seen to promote sustainable composting are summarized below, and show clearly how some incentive "carrots" are effective in balancing the "sticks" where the diversion is being sustained.

- **Comprehensive composting programs** that provide for year-round collection of many types of yard waste at curbside and incentives for landscapers to compost their yardwaste
- **Mandatory participation** achieved by suitable legislation at the State or municipal level, as may be appropriate
- **Recovery of materials from single and multifamily households, and from commercial and institutional establishments** (through both curbside and drop-off collection, paid for by taxes or by user-pay schemes)
- **Targeting a wide range of materials for recovery**, to spread collection costs over a variety of potential recycled products, not just on compost
- **Economic incentives for materials recovery** (volume-based refuse rates, reduced tipping fees for recyclable or compostable materials at drop-off sites, and higher tipping fees for disposal of mixed refuse)
- **Convenient pick-up of materials** at curbside, from central containers located at easily-accessed public places, or from municipal depots
- **Provision of adequate containers** for setting out materials at curbside and for temporary sanitary storage in the dwellings
- **Education and publicity**, by a wide variety of strategies that includes "Master Composter" programs, seminars at community colleges, demonstrations at fairs, rodeos and other events, spots on local radio and television

The report indicates that composting tends to have a more significant effect on the residential waste recovery levels than on the overall waste stream of the community. Turning to a few notable specifics, Woodbury, NJ composts 13% of its total waste, but 24% of its residential waste stream. Moreover, the types of materials targeted for composting and the frequency of pick-up affect the capture level, an observation confirmed by a very recent pilot project in Mississauga, ON.[120] Three out of the four programs with the highest residential composting levels have year-round collection of leaves, brush and wood waste (which would not be a significant benefit in most Alberta situations) and seasonal collection of Christmas trees (which would).

Curbside collection in the city of West Lynn, OR is charged at a steep monthly rate on a per-container basis, so the 14,000 residents tend to bring their yardwaste to a conveniently situated drop-off site or compost it at home. Composting seminars are laid on at the local community college. A 15% - 20% diversion rate is claimed for this strategy.

Wellesley, MA offers its population of 26,500 no municipal curbside collection of refuse, recyclables or compostables at all, but encourages all residents and businesses to make use of two designated drop-off sites. It still manages over 40% diversion.

Table 7.1 **TOTAL MATERIALS GENERATED AND RECOVERED, 1989**

3 Community	Type	Population	Total Waste Generated (Tons) (a)	Per Capita Residential Waste Generation (lbs/day)(b)	Total Recycled (Tons) (c)	Total Composted (Tons)	Total Recovered (Tons)	% Total Recycled (By Wt)	% Total Composted (By Wt)	% Total Recovered (By Wt)(d)
1 Berlin Twp, NJ	S	5,629	7,778	4.7	2,501	1,900	4,401	32	24	57
2 Longmeadow, MA	S	16,309	10,891	3.2	1,934	3,424	5,358	18	31	49
3 Haddonfield, NJ	S	12,151(e)	13,681	5.5	2,471	4,207	6,678	18	31	49
4 Perkasie, PA	S	7,005	2,794	2.4	831	380	1,211	30	14	43
5 Rodman, NY	R	850	352	2.2	114	36	150	32	10	43
6 Wellesley, MA	S	26,590	23,030	NA	3,581	5,831	9,412	16	25	41
7 Lincoln Park, NJ (f)	S	11,337	11,011	3.3	3,728	817	4,545	34	7	41
8 West Linn, OR	S	14,030	8,584	3.4	1,940	1,480	3,420	23	17	40
9 Hamburg, NY	S	11,000	6,050	2.6	1,360	1,062	2,422	22	18	40
10 Wilton, WI	R	473	226	2.3	80	10	90	35	4	40
11 Seattle, WA	LC	497,000	672,024	3.2	200,914	42,904	243,818	30	6	36
12 Cherry Hill, NJ	SC	73,723	108,856	3.8	29,479	9,046	38,525	27	8	35
13 Upper Twp, NJ	R	10,870	16,474	NA	2,542	3,262	5,804	15	20	35
14 Babylon, NY	LC	213,234	271,750	3.4	91,566	1,000	92,566	34	0.4	34
15 Park Ridge, NJ	S	8,515	9,990	4.4	2,580	815	3,395	26	8	34
16 Fennimore, WI	R	2,430	1,692	1.9	453	125	578	27	7	34
17 Woodbury, NJ	S	10,450	15,829	4.6	2,951	2,085	5,035	19	13	32

KEY: LC = Large City R = Rural S = Suburb SC = Small City NA = Not Available

NOTES:
(a) Materials disposed and recovered by residential, commercial, and institutional sectors. Bulky waste disposed is included in total waste generation with the following exceptions: Fennimore, Berlin Twp, Wilton, and Longmeadow. Some bulky waste is included for Perkasie, Hamburg, Seattle, Cherry Hill, Upper Twp, and Park Ridge. See case studies for more detailed informaiton on what is included or excluded from total waste generated.
(b) West Linn's figure is based on total waste generated. Seattle's figure includes self-haul waste, of which 50% is estimated to be residential.
(c) Includes estimated tonnage recycled through beverage container deposit systems.
(d) Due to rounding figures, Percent Total Recycled plus Percent plus Percent Total Composted may not appear to equal Percent Total Recovered.
(e) Based on 1988 data.
(f) All figures for Lincoln Park based on 1988.

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Encouragement of particular target subsets of the community also prove useful, and lead to significant additional diversion. Sixteen of the seventeen communities studied directly encourage commercial waste recovery through a variety of strategies, giving economic incentives to businesses and private haulers who serve the *ICI* community. Landscapers, greenhouses and other volume generators are given a special deal at the landfill in Longmeadow, MA, where the tipping fee of US$23/ton (CN$34/tonne) is waived for yard waste brought there by the operator for disposal, increasing the city's overall diversion rate by 7%.

The list of possibilities is long, but the overall trend is clear. Encouragement of the desired action is best achieved by a balance of bans and incentives, the precise mix being dictated partly by higher authority and partly by the democratic decision of the community themselves, since what suits one situation may not be equally applicable to all.

7.3 Beginning at Home - Encouraging Home Composting

Numerous studies across the United States and increasingly in Canada suggest that backyard composting can have as dramatic an effect in establishing a composting ethic as the Blue Box programs have on overall recycling. It has been promoted in the City of Waterloo, ON with most encouraging results[121], and in the Region of Durham, ON where it is now regarded as "the first step in organic waste management".[122] Each community uses different outreach and assistance programs, but the message to residents is the same: *"Never have your food and yard waste leave home if you can manage it"*.[123]

To promote the switch from a negative NIMBY syndrome to the positive YIMBY, "Yes, in my backyard", a number of US and Ontario cities have taken the decision to distribute backyard composters to residents either free, or at a significantly subsidized cost. Metro Toronto made available 100,000 home composting units of varying design to suit personal preferences, in a pilot area at a nominal cost of $10 ($15 for those who wanted it delivered to the home), and also developed a special unit attractive to apartment dwellers. The costs were shared about 1/3 - 2/3 between Metro Toronto and the province. In contrast, Marion County in Oregon buys a variety of composters in bulk direct from the manufacturers and sells them on at a rate which reflects the bulk purchasing discount. Sales in 1992 were reported to far exceed the county's expectation. The promotion cost the county between $5,000 and $10,000[124] but, as noted in the Ontario studies, this is "a fraction of the cost of conventional waste management systems"[125] and has had a marked effect on the general public awareness of the communal benefits of recycling.

Before launching such a program, especially if it is based on a mandated ban of one form or another of waste from the landfill, it is essential to have the necessary civic infrastructure in place in good time,[126] before the legislation "bites". The City of Edmonton waited until there was a viable alternative before imposing a deterrent disposal rate on tires at the city landfill. The bylaw was passed in Council, but not implemented until a tire recycling company was established.[127] Home scale composting is exempt from the requirements of permitting by the Board of Health, and thus proves to be a straightforward first step in the overall composting process.

The larger picture should have been put on the canvas before any mandating or bans come into effect. Several composting plants planned and built in the Minneapolis area are now suffering a significant upset in their feedstock balance because a backyard composting mandate was placed on residential yard wastes *after* they had been built with yard waste as a prime ingredient of their mix.[128]

The hand-holding of first-time home composters needed for sustained use of these programs is substantial.[129] Vancouver, BC, King County, WA and other pioneers of widescale home composting have found, like Edmonton, that Master Recycler and Master Composter programs based on volunteers from all walks of the community an essential back-up to their municipal initiatives. While admitting that the return on their investment is difficult to quantify, the management of the Solid Waste Division of King County still asserts that "the Master Recycler Composter program is an investment that will pay off now and for years to come. When you have a group of people who are willing to volunteer their time and enthusiasm, the least we can do is share their commitment with some resources to make them as effective as possible".[130] Some restrictions on backyard composting have been noted elsewhere in this study, such as the ban imposed by Parks Canada within the mountain parks, but the overall achievements of this level of composting can still be impressive.

A parallel service has been developed in Vancouver to assist those not yet familiar with all the intricacies of home composting, the Vancouver Compost Demonstration Garden and the Compost HotLine, both managed by ***City Farmer***. This organization publishes a series of research notes on all aspects of composting, from components of an ideal composting mix to the effects of pesticides and avoiding infestation by rats and other predators.[131] The Action on Waste Recycle Info Line is now set up to respond to calls on backyard (home) composting.[132]

7.4 Bringing in Professional Help - Food Waste and Other Organics

Many successful composting programs have begun with a single resource or a simple mix, and expanded their capacity progressively to deal with a broader diversity of organic wastes. The University of Guelph began a mixed waste composting trial on behalf of the city in 1991. Guelph is

now operating a wet/dry separation system aimed at composting a large portion of its organic waste, keeping residents up-to-date through an informative broadsheet.[133] Three of the boroughs in the Greater Toronto Area (GTA) have engaged the services of the same department at the University of Guelph to assist them in a pilot scheme involving some 40,000 residents of Etobicoke, North York and Toronto, set up in late 1991, to involve not only residential sources but also the *ICI* sector in composting multiple organic wastes.[134] The Province of New Brunswick has commissioned a study by the University of Moncton aimed at composting in the ICI sector, which will bring in manures, farm and fish processing wastes, residues from the timber industry and other assorted organics.[135]

The information freely distributed over the Compost HotLine in Vancouver includes advice on co-composting manures, seaweed and sludges[136], while the City of Waterloo is expanding its own yard waste program to include supermarket wastes, and the necessary background study to implement this proposal has formed the basis for a Master's Degree program at the University.[137]

To assist composters with their early moves into this field and to help avoid costly mistakes, the Massachusetts Department of Food and Agriculture has cooperated with the Environment Department to prepare a slim booklet advising farmers how to find their way through the complex regulatory procedure, how to obtain necessary permits and conduct their composting operations with the minimum of hassle.[138] The BC Ministry of Agriculture produces a similar basic guide, aimed principally at householders and farmers but of great use to smaller municipalities who do not have their own in-house expertise.[139] A larger, more comprehensive guide covering the ground in far greater detail is produced by the (US) Northern Regional Agricultural Engineering Service in Ithaca, NY.[140] All these aids to sustainable composting are the result of thoughtful pro-active work by the authorities involved with the regulatory process in each jurisdiction involved, sometimes by more than one department.

A noteworthy part of the Massachusetts plan to broaden the base of composting as a viable and sustainable waste diversion strategy, which is mirrored in legislation in New Jersey, Idaho and Ontario, is to allow *"permitting by rule"*. Under this special user-friendly legislation, facilities composting no more than a given threshold amount (20,000 yd^3/year in NJ) must register their operation with the proper local regulating authorities and agree to abide by established regulations and guidelines. The long-drawn-out formal permitting process is then waived. Alberta equivalent authorities should note that "surprisingly few problems" are reported with this procedure.[141] One major lesson to be learned from the successes of other jurisdictions is that, for composting to succeed as a viable strategy in accomplishing the laudable aims of the Canada Green Plan, provincial and municipal authorities must be perceived to work *together with* prospective composters, not just erect hurdles in their way in the very correct name of "environmental protection". A recurring theme in the responses of delegates to the Olds College Workshop in July 1993, summarized at Section 5.3.8 in this report, was the need for all levels of the jurisdictions involved with regulating composting to be as well educated in the complexities and simplicities of the process as the composters themselves will have to be.

7.5 Feeling One's Way Forward - The Importance of Pilot Programs

Reference has been made above to *pilot projects* undertaken by several of the cities in Ontario who have embarked on composting programs. Reports on several of the earlier ones are now readily available, and have been cited in these notes. It could well prove a valuable exercise to examine the schemes across Canada listed in the Review by the Composting Council[142] and correlate their most obvious successes and failures as a lesson to others who would walk the same path.

Pilot programs are particularly valuable because a number of the variables discussed in this Report are still somewhat a matter for conjecture in Alberta. For instance, the quantities of *compostable* organic waste material generated in each of the model communities on which the study is based are drawn from real empirical audits and surveys. But the collectable quantities on which real composting schemes will need to be based depend on an accurate assessment of the local *capture rates*, which are largely unknown until a pilot project is undertaken. The Procter & Redfern Interim Report is of particular value in this respect, showing both a fairly consistent range of participation rates within the pilot communities and a range of capture rates on which real programs there can now be based.[143]

While the merits of source separation are universally agreed as a criterion for the production of a top class compost[144], expert opinion is divided on whether greater success is achieved with a 2-stream wet/dry collection, or a 3-stream system keeping dry, compostable and other wastes apart. Paul Taylor's review of early Toronto trials comes down clearly in favour of a 2-stream system[145], much like the City of Guelph. People seem to be willing to do the extra work required in 2 stream separation, but get confused or just plain fed up with anything more complex. Procter & Redfern, however, elect for a 3-stream collection as a result of their pilot process. It is far from clear that one system or the other is always superior in all situations, and time and resources could well be invested in deciding what is best by observation at pilot level in any given community. These schemes will require assistance in all but the most self-sufficient communities in Alberta, but the scale of the funding is modest and the risk more easily contained.

Nor is the economic benefit all one way. The revealing

studies by the Institute for Local Self-Reliance indicate that, when composting and recycling are taken as two parts of one composite program, there is a very valuable second-order of economic benefit generated in the entire community. It is calculated, for instance, that the value added by recycling industries and composting in Massachusetts (admittedly a long way from Alberta, but the trend is still noteworthy) came to US$588,000,000 in 1991 and sustained almost 9,500 jobs.[146] The overall benefit to the Province of Alberta would go far beyond the saving from diversion of waste from landfills, excellent as that is in its own right. And the compost produced could have a value beyond its market price, in terms of priceless agricultural land maintained in production.[147]

Many of these programs have been carried out by a municipality in conjunction with a consultant and an academic institution.[148] Much of the groundwork for recent studies in Jasper National Park was based on a Master's Thesis study for a campus composting program at the University of Calgary.[149] The initiative pursued by Riverbend Penitentiary and the City of Prince Albert, and by Olds College and the Greenleaf Company, could well be models for similar cooperative ventures, based on federal or provincial institutions pioneering a process at the pilot scale and later extending it to embrace the neighbouring communities.

7.6 Municipal Strategies - Lessons from Other Cities

At any level higher than that of the home, composting as envisaged in this review is likely to be undertaken as a private venture at almost any scale, from the 10 tpd plan for Edmonton's 184th Street to the 650 tpd proposed by a private corporation based in Coronation, AB. As a municipal undertaking, most proposals appear likely to be geared towards meeting the immediate needs of a distinct community, "closing the loop" in local waste management. But these initiatives at the municipal level will be greatly affected, for better or for worse, by the leads taken by the province, just as they are by State legislation in the United States.[150]

Examples of municipal initiatives are summarized below. provincial initiatives parallel to the Beverage Container Act will undoubtedly have a powerful effect in shaping the progress of the province's towns and cities towards truly sustainable composting, because this is where the power for initiating effective action is concentrated.

Summary of helpful strategies:

- **Establish the best available information base beforehand.** Waste quantities and composition studies provide the basis for all further planning. It is not sufficient to rely on "broadly accepted norms", which generally relate to some other community and are often years out of date.
- **Set up a modest Pilot Project, with expert assistance if necessary.** There are several federal and provincial funds, and even some from the private sector, available to assist with well conceived projects involving a municipal compost program[151].
- **Start at the level of the home.** Home composting can be done by virtually anyone, and can divert anywhere from 7% to 25% of a community's organic wastes if a reasonable number can be persuaded to join in.
- **Promote the scheme with both sticks and carrots.** Assisting home composters to get started with subsidized equipment has been found to be far less costly than conventional waste management. Subsidizing their purchase is preferable to giving them away, since an outright gift does not involve the recipient in any commitment to keep on using it.
- **Make it as easy as possible for the community to follow the plan.** If pick-up is to be discouraged, place suitable containers at convenient places so that it is easy to use them.
- **Extend such schemes to schools** and similar places of public exposure. Peer pressure has a powerful effect on less enthusiastic members of the community, even if not *everyone* joins in.
- **Develop comprehensive plans** that can be implemented in stages, so that individual initiatives will relate to a common master strategy.
- **Extend the scope of the program by degrees,** making sure that the necessary infrastructure is developed in advance of any legislation that requires it to be in place.
- **Make use of all media publicity available** to inform the participating public of the plans, their successes and, if necessary, their partial failures.
- **Involve established centres of research and technology.** These may be private, such as the Woods End Laboratories in the United States, a most highly respected research centre in this field, as well as the established Universities and Colleges where the next generation of experts is being trained and needs practical experience to blend with their theoretical training.
- **Seek cooperation with all levels of government and with the private sector.** Grants are not the only way to go. Private initiative is cautious with its investments, and tends to plan well.
- **Work for a well informed administration** at every level, and seek pro-active initiatives that "put the money where the mouth is", for instance by buying the locally produced compost for municipal and provincial public works.
- **No one solution is likely to fit all situations.** Communities differ, as shown in the model Alberta communities set up for this study. Their waste streams

are not identical, nor are their favoured methods of collection and disposal. What suits a community best will probably work best.

Examples of leaders in the field:

Examples too large to cite in total in the text are included in the Reference section. Attention is particularly drawn to:

- **Seattle, Washington,** a Case Study by the Institute for Local Self-Reliance, Washington, DC, 1991. The city's Waste Management plans are summarized, and the progress is charted through pilot projects and full-scale materials recovery programs. Source reduction, curbside collection, recycling and composting activity is described, with a tabulation of the actual achievements in the residential and commercial sectors.
- **The City of Guelph, Ontario,** Wet/Dry Recycling Program, May 1993. The reasons for wet/dry recycling are reviewed and a processing facility is described in sufficient detail to make participants aware of the bigger operation they are a part of. Its costs and benefits are discussed, the essentials of composting are outlined and a number of health concerns are addressed.
- **City of Waterloo, Ontario,** Yard Wastes Initiatives Update, April 1992. Pilot projects aimed at significant waste reduction through yard waste composting in the city are reviewed in essential detail for the City Council, to assist in making informed decisions about the future of proposals for extending the programs. A chronology of the step-by-step implementation of the Master Plan is included, with examples of the Public Awareness outreach.
- **City of Aarhus, Denmark,** *Sortér dit affald,* in English translation "Sort your Refuse", leaflet for public information introducing the city's comprehensive recycling and composting plan to reduce landfilling to a maximum of 20% by the year 2000. Denmark has always been at the forefront of European recycling and composting and Aarhus, the second city of Denmark, is comparable in size to Edmonton. The pamphlet explains the Council's aims to the residents and describes the variety of waste management and recycling strategies adopted to ensure success.

It is hoped that these will provide a practical guide to those of our own municipal authorities who do not yet have the experience or the resources to prepare or plan such programs on their own, showing how the principles discussed in the text are applied in practice and the results are assessed.

7.7 Relative Costs

In order to measure financial sustainability, each community generator model was viewed in relation to the estimated operational costs that might be incurred if the recommended compost program or process (Table 6.1) was employed. The following six cost scenarios trace the expected annual costs in the form of collection from both the residential and ICI sectors. The approximated costs of operations, collection and transportation associated with the cost scenarios do not include change over costs to a wet/dry collection system and capital costs associated with land and equipment. The cost scenarios are based on average collection costs presently charged by industry and municipal solid waste collection systems. It is assumed that the waste cost diversion of the wet compostable material may have a savings associated with collection, which would presumably be offset by the collection of the dry material.

These calculations are compared with the average costs of landfilling within each community scenario and the resulting per tonne cost for each method is presented. In all cases, the average costs shown for landfilling are based upon known industry costs, which in the case of Alberta, are known to exhibit great variances depending upon jurisdiction. For example, the cost for tippage in Calgary is significantly less than the tippage fee in Edmonton, which ranges between $40 to $60 per tonne based upon the type of waste being discarded. Similarly, tippage costs in smaller Alberta centres can range from $5 per metric tonne to $20 per metric tonne.

The basis for measurement in all cases is the gross amount of feedstock available in the MSW stream. The only exceptions shown are in the Town - Farm model wherein manure is added to the compostable quantities and in the Town - Non-Farm model where 23% of the organic waste stream (in the form of cardboard) has been excluded. These exceptions are shown as a means to demonstrate that program options can vary widely and have a direct effect in predicting costs. Section 9 provides an additional look at the impacts of composting in Small Town Alberta by tracing a generic study.

Cost Scenario - Model #1 - Village

- feedstock quantities based on collection and processing 100% of available feedstock (from Table 4.2)
- 400 residents — 1 M.T. / capita / year
- 150 dwellings curbside collection $3.50 / residence / month
- Commercial Industrial and Institutional collection is user pay
- all calculations on yearly costs
- landfill fees $15.00 M.T.
- composting operational costs $25.00 / M.T.
- village does not have a recycling program (cardboard, etc.)
- wet / dry separation at source by resident (colour coded bags)
- commercial waste separated wet / dry (pre-sorted)
- capital costs not included ($50,000 - $100,000)

Present costs to landfill organics		Costs to compost organics	
Residential Collection 150 residences — $3.50 / residence / month (134 M.T.)	$6,300	Residential Wet/Dry Collection 150 residences — $3.50 / residence / month (134 M.T.)	$6,300
Commercial collection (113 M.T.)	$2,500	Commercial collection (presorted) (113 M.T.)	$2,500
Landfill cost 247 M.T. — $15.00 / M.T.	$3,705	Landfill Cost Composting operational 247 M.T. — $25.00 / M.T.	$6,175
	$12,505		**$14,975**
or $50.63 per metric tonne		*or $60.63 per metric tonne*	

Landfill costs — $25.00 / M.T. would allow the economic viability of composting

Summary:

The village model as depicted may not require a sophisticated process for composting. As in many rural areas, employing used equipment and facilities would lower the operational costs. The collection costs may be reduced by virtue of proximity to the composting area allowing for drop off of many materials (yard waste, etc.) from the residential as well as cardboard from the commercial component.

It must be noted that as landfill prices increase, or as landfills are closed, composting becomes more viable in villages.

Cost Scenario - Model #2 - Town / Non-Farm

- feedstock quantities based on collection and processing 100% of available feedstock (from Table 4.3)
- 3000 residents — 1 M.T. / capita
- 1000 dwellings curbside collection $3.50 / residence / month
- Commercial, Industrial, Institutional collection is user pay
- all calculations on yearly costs
- landfill fees $15.00 / M.T.
- composting operational costs $25.00 / M.T.
- town has a cardboard recycling program (23% taken out)
- wet / dry separation at source by residents (colour coded bags)
- commercial waste - cardboard collection - all other organics attainable for composting
- capital costs not included ($75 - 150,000)

Present costs to landfill organics		Costs to compost organics	
Residential Collection 1000 residences — $3.50 / residence / month (858 M.T.)	$42,000	Residential Wet/Dry Collection	$42,000
Commercial collection (1500 M.T.)	$33,000	Commercial collection	$33,000
Landfill cost 2357 M.T. — $15.00 / M.T. less 23% OCC	$35,355 -7,600	Landfill cost Composting operational 1815 M.T. — $25.00 / M.T. (less OCC)	$45,375
1815 M.T.	**$102,755**	1815 M.T.	**$120,375**
or $56.61 per metric tonne		*or $66.32 per metric tonne*	

Landfill costs — $25.00 / M.T. would allow the economic viability of composting

Summary:

The Town / Non-Farm model as described is unique as OCC is extracted from the waste stream to show the effect on the cost per tonne. The effect of this is directly related to the difference in costs between landfill costs and compost operational costs ($10.00 more / M.T. to compost). It also should be noted that with most non-farm communities, industry is commonly associated. It is shown in the feedstock quantities for non-farm that utilizing the available wood waste residue from forest products drastically changes the volumes available as well as the carbon to nitrogen ratio.

Cost Scenario - Model #3 - Town and Farm

- feedstock quantities based on collection and processing 100% of available feedstock (from Table 4.4)
- 3000 residents — 1 M.T. / capita / year
- 1000 dwellings curbside collection $3.50 / residence / month
- Commercial, Industrial and Institutional collection is user pay
- all calculations on yearly costs
- landfill fees $15.00 / M.T.
- composting operational costs $25.00 / M.T.
- town has no significant recycling program
- farm manure added to composting
- wet / dry separation at source by residents (colour coded bags)
- capital costs $100,000 - $200,000 not included

Present costs to landfill organics		Costs to compost organics	
Residential Collection 1000 residences — $3.50 / residence / month (857 M.T.)	$42,000	Residential Wet/Dry Collection	$42,000
Commercial collection (1438 M.T.)	$31,636	Commercial collection	$31,636
Landfill Cost 2295 M.T. — $15.00 / M.T.	$34,425	Landfill cost Composting operational 2295 M.T. — $25.00 / M.T. add 2000 M.T. manure — $25.00 M.T.	$57,375 +$50,000
2295 M.T.	**$108,061**	4295 M.T.	**$181,011**
or $47.08 per metric tonne		*or $42.14 per metric tonne*	

Landfill costs — $25.00 / M.T. would allow the economic viability of composting

Summary:

The Town / Farm community ICI make-up is not only for the residents; consideration has been made for the rural resident using the business and tourism facilities.

The most significant difference in this model from the other community models is the available manures from local farms which could be captured for the composting operation. Town and Farm communities may have the capability to operate a composting operation for less than the costs shown in the model. Farm equipment and land may be available along with the manure feedstock to make a financially viable operation.

Cost Scenario - Model #4 - Small City

- feedstock quantities based on collection and processing 100% of available feedstock (from Table 4.5)
- total landfill waste — 19,685 M.T. (or 1 M.T. / capita / year)
- collection cost taken at 7022 dwellings with curbside collection — $3.50 / residence / month
- Commercial, Industrial and Institutional collection is user pay
- all calculations on yearly costs
- landfill fees — $15.00 / M.T.
- composting operational costs $65.00 / M.T.
- compost scenario assumes wet / dry separation at source by residents (colour coded bags)
- capital costs $500,000 - $1,500,000 not included

Present costs to landfill organics		**Costs to compost organics**	
Residential Collection 7022 residences — $3.50 / residence / month (5775 M.T.)	$294,924	Residential Wet/Dry Collection	$294,924
Commercial collection (7620 M.T.)	$167,640	Commercial collection	$167,640
Landfill Cost 3,395 M.T. — $15.00 / M.T.	$200,925	Composting operational 13,395 M.T. — $65.00 / M.T.	$870,675
13,395 M.T.	**$663,489**	13,395 M.T.	**$1,333,239**
or $49.53 per metric tonne		*or $99.53 per metric tonne*	

Landfill costs — $40.00 / M.T. would allow the economic viability of composting with a consideration that existing municipal equipment could be used or that a smaller scale operation (windrow or a static pile) is an option.

Summary:

Small cities commonly engage large commercial waste haulers with collection rates which vary depending on present systems utilized (i.e., carts, containers or hand pick up), therefore, the calculation of cost becomes unique to each community's contract situation.

Cost Scenario - Model #5 - Large City

- feedstock quantities based on collection and processing 100% of available feedstock (from Table 4.6)
- total landfill waste — 614,665 M.T. (or 1 M.T. / capita / year)
- 25,000 dwellings with curbside collection
- Commercial, Industrial and Institutional collection is user pay
- all calculations on yearly costs
- landfill fees — $40.00 / M.T.
- wet / dry separation at source by residents
- assumes significant recycle programs in operation
- capital costs $10 million - $25 million (hybrid channel or in vessel composting system)

Present costs to landfill organics		Costs to compost organics	
Residential Collection 250,000 residences — $3.50 / residence / month (209,000 M.T.)	$10,500,000	Residential Wet/Dry Collection	$10,500,000
Commercial collection (281,957 M.T.)	$6,203,054	Commercial collection	$6,203,054
Landfill Cost 490,957 M.T. — $40.00 / M.T.	$19,638,280	Composting operational 490,957 M.T. — $65.00 / M.T.	$31,912,205
	$36,341,334		**$48,615,259**
or $74.02 per metric tonne		*or $99.02 per metric tonne*	

Summary:

The Large City has many variables in each category and, therefore, an attempt to show the cost per metric tonne for this model is not practical. The capital cost is a major factor in the economic viability.

Cost Scenario - Model #6 - Resort Community

- feedstock quantities based on collection and processing 100% of available feedstock (from Table 4.7)
- total landfill waste — 8500 M.T. (or 1 M.T. / capita / year)
- 1000 dwellings with curbside collection
- Commercial, Industrial and Institutional collection is user pay
- all calculations on yearly costs
- landfill fees — $15.00 / M.T.
- compost scenario assumes wet / dry containers provided in community for drop off
- sensitive ecological balance to be preserved
- capital costs $125,000 - $500,000

Present costs to landfill organics		Costs to compost organics	
Residential Collection 1000 residences — $3.50 / residence / month (1324 M.T.)	$42,000	Residential Wet/Dry Collection	$42,000
Commercial collection (6888 M.T.)	$151,536	Commercial collection	$151,536
Landfill Cost 8212 M.T. — $15.00 / M.T.	$123,180	Landfill Cost Composting operational 8212 M.T. — $35.00 / M.T.	$246,360
	$316,716		**$439,896**
or $38.56 per metric tonne		*or $53.56 per metric tonne*	

Landfill costs — $35.00 / M.T. would allow the economic viability of composting

Summary:

The Resort model has a significant difference in the landfill cost per metric tonne to compost organics. The reasons for this are that the commercial sector has a larger contribution than the norm, due to the population increases during tourist seasons. It is also a highly regulated area with higher operational costs associated with composting.

Cost Scenario - Model #7 - Integrated Region

- feedstock quantities based on collection and processing 100% of available feedstock (from Table 4.8)
- total landfill waste — 7,436 M.T.
- 4220 dwellings
- Commercial, Industrial and Institutional collection is user pay
- all calculations on yearly costs
- landfill fees — $15.00 / M.T.
- wet / dry separation at source by residents
- assumes composting operational costs — $45.00 / M.T.
- capital costs $500,000 - $1,500,000 not included

Present costs to landfill organics		Costs to compost organics	
Residential Collection 4220 residences — $3.50 / residence / month (2803 M.T.)	$117,726	Residential Wet/Dry Collection	$117,726
Commercial collection (2936 M.T.)	$ 64,592	Commercial collection	$ 64,592
Landfill Cost 5739 M.T. — $15.00 / M.T.	$86,085	Landfill Cost Composting operational 5739 M.T. — $35.00 / M.T.	$200,865
	$268,403		**$383,183**
or $46.76 per metric tonne		*or $66.76 per metric tonne*	

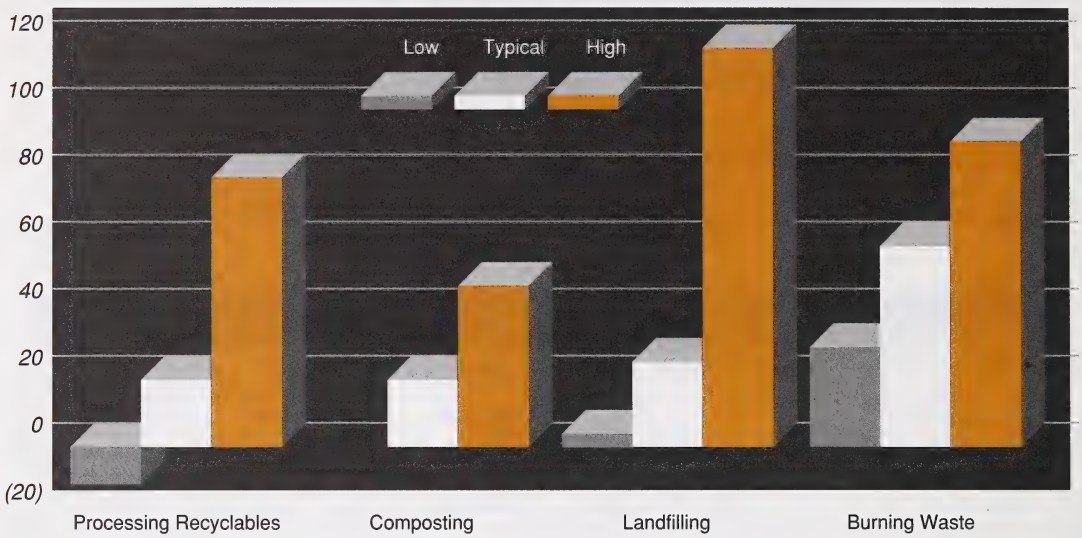
Due to the number of variables in this model, no reasonable cost estimates can be given for economically sustainable composting.

Summary:

A regional system with incorporation of a major city may involve a highly technical operation costing $20 - 40 million expenditure although, depending upon the make-up of the region, a windrow or static pile system may work satisfactorily. The use of available equipment also must be a consideration.

In a regional setting there may be additional transportation costs from participating communities to a centralized location. These costs must be considered in planning exercises.

Figure 21 ***Per Ton Tipping Fees at Processing and Composting Facilities, Landfills, and Incinerators***



Summary:

The previous tables demonstrate that the cost of composting, at today's rates are somewhat higher than the costs of conventional landfilling in Alberta. However, programs that have been underway in US communities show that, because of the rising cost of landfilling, (which is generally higher than Alberta averages), composting has evolved as a lower cost alternative.

Unlike incineration or landfilling, composting must be approached as a system. Conventional waste management strategies allow everyone to dump everything into a single container; the waste is then compacted and either sent to a landfill or to an incinerator. Composting programs must use a comprehensive approach, combining public education, careful attention to the mechanics of collection, and market development by material. Approaching solid waste management in this fashion can reap the benefits of lower costs, job creation and new enterprise development.

Cities facing economic recession and ever tightening budgets may be tempted to cut back on their recycling programs. Such cutbacks may save money in the short run, but they will cost money in the long run. Unless a community is located near high capacity, low cost landfills, waste reduction, recycling and composting are the cost effective strategy. The per ton costs of start up and pilot programs may be higher than those of conventional solid waste management alternatives. This is to be expected. But as the programs expand, the costs will come down. Communities around the country have experienced a dramatic learning curve in the last five years, learning how to pick and process materials more efficiently, and how to identify new markets for these materials.

In good times and in times of hardship, we need to extract the maximum value from our raw materials[152].

Sustainable composting in any given jurisdiction must be viewed from the perspectives of:

- **Social Acceptance** and the overall predisposition, or mindset, of a community's constituents to engage in composting at any level;
- **Environmental Compatibility** or the degree to which the activity recovers renewable resources in a safe and health conscious manner and utilizes them at rates which preclude depletion;
- **Physical Feasibility** or the ability of an individual or community to recognize compostable feedstock, get hold of it, process it and utilize its end products;
- **Economic Viability** or the ability to undertake composting at costs which are affordable to the individuals or community.

This study traces the many constraints which lie as roadblocks to the successful achievement of the above noted conditions for sustained composting. In doing so, it also reveals opportunities, or those positive conditions and influences which will fuel the successful growth of composting within the province. Following on Table 8.1 is a summary of the major constraints and opportunities which now exist within the province.

Also included are accompanying strategies which hopefully will serve as a catalytic base from which local, regional and province-wide programs can evolve.

Table 8.1 - Summary of Constraints and Opportunities

Social Acceptance

Constraints	Opportunities	Action / Direction
There exists a low level of composting awareness and understanding particularly with respect to the process and the value of compost as a soil additive.	Albertans are becoming increasingly aware of the costs and the environmental problems associated with incineration and landfilling and are open to explore initiatives which are more environmentally compatible.	Provincial and local level governments, groups and associations must increase advertising efforts and develop coordinated province-wide marketing strategies aimed at heightening the positive aspects of composting as an acceptable alternative to landfilling.
Many smaller communities are not yet faced with the need to explore alternatives for waste reduction because they have extended capacity within their landfills and have minimal costs compared with major cities.	same as above	same as above; and, Local governments and regional waste management systems should be encouraged to develop long range strategies for waste minimization and should be made better aware of overall national and province-wide goals of reducing waste by 50% by the year 2000.
To date, most waste reduction and recycling programs are voluntary activities with few legislated deterrents or policies - thus there are inequities in the individual efforts of residents.	Most Albertans recognize and are receptive to any programs that are aimed at environmental preservation. They have demonstrated a willingness to respond to reasonable legislation which provides for user-pay options.	Municipalities should develop strategies which incorporate user-pay options for waste removal on a progressive basis. Constituents must be apprised of programs and future deterrents that will be employed as a means to divert waste through composting. Residents must also be apprised of composting as a viable alternative for waste reduction.
Some people view composting as a messy and odour filled activity and there are a number of health and safety issues associated with composting at all levels.	Process technology is advancing on a daily basis and, as well, the province is developing guidelines to overcome related health and safety issues.	Backyard composting campaigns and related literature must accentuate the need for the education and commitment associated with proper procedures. Guidelines for composting at all levels must be advertised and employed and the permitting process for composting operations must be clearly defined.

Constraints	Opportunities	Action / Direction
Improper design and processing can result in ground water contamination, air born contaminants, vermin and a host of environmentally related problems.	Through selection of appropriate composting methods, increased technology, improved designs and enforced guidelines, potentially hazardous environmental impact can be reduced or eliminated.	Development and use of guidelines are required.
The use of sewage sludge in the process has negative reviews from the public perspective and requires screening of heavy metals prior to use as a feedstock.	Composting is a natural process and does not require chemical or artificially induced catalysts. The product is also natural. Compost can reduce the dependence upon chemical based soil additives - thus hazardous environmental impacts are reduced.	Governments should increase their focus upon the environmental economics associated with composting versus other forms of soil improvement. The impacts of sewage sludge spreading versus the application of compost (and compost mixes which may or may not include sewage sludge) must be further researched.
The waste diversion potential of composting is not widely known as recycling programs have evolved as the primary and initial focus.	Municipalities are now seeking viable alternatives to landfilling, have recognized that recycling and reduction have a significant effect, and are curious about the utilization of composting as an additional means of recovery.	Publicize the positive impacts of composting in respect of its waste diversion potential and make people recognize that non-recycled organics can make-up between 40% and 50% of the waste stream.

Constraints	Opportunities	Action / Direction
A number of community based composting pilot programs have failed and follow-up monitoring is seldom publicized.	Many municipal backyard composting programs are being implemented and many community programs have been successful, such as that at Olds College where the collection, processing, testing and marketing of compost is well under way. The college is also developing a comprehensive curriculum and knowledge base and is considered to be the centre of research and development for the province.	Provincial and local governments and associations must increase their efforts in developing: • accessible compost data bases • leadership resources • resident and practitioner based training programs • compost seminars • compost manuals and training aids • developmental consultation • monitoring programs • demonstration sites
Collection and transportation is viewed as an area requiring attention in most communities. Voluntary separation at source is viewed as a requirement if the composting is to be affordable and of consistently high quality.	Many communities such as Olds, Drumheller, Innisfail and Brooks have developed simple but effective collection systems for yard waste which require residents to deposit brush, leaves and grass in containers placed throughout the community. Other communities such as Sherwood Park have incorporated clear bag pick-ups for leaves as part of the regular service. Although the process of de-bagging (emptying plastic bags) and waste has been found to be costly because of the man hours required (e.g., Edmonton), new truly biodegradable bags are entering the market and although more costly than conventional bags at the present, future demand may result in mass production and thus less cost. Regional transfer of waste and related transfer station systems are evolving.	Municipalities must continue to explore innovative volunteer collection programs and keep abreast of new products and technologies which improve collection. The waste hauling industry must be encouraged to explore alternatives which provide for commercial and residential collection of compost feedstocks. Continue to encourage the inclusion of compost feasibility studies in all waste management plans.
Climate is viewed as a deterrent in Alberta since the composting process slows down or stops in winter months. Process technology is not well understood by municipal public works personnel.	Private and municipal representatives who attended the Olds Composting Workshop were very interested in the ability to access information and educational opportunities related to composting under varied conditions.	Circulate publications, research and research results. Strengthen provincial networking through the development of regional associations or offshoots of current associations like the Alberta Recreation and Parks Association.
Practitioners in some areas (particularly smaller jurisdictions) believe that end markets for compost must be developed before programs are put in place. This is particularly true within the private sector.	Many communities have successful community-wide compost programs which provide free compost to participants (Brooks is one example).	Identify and publicize the important uses of compost at the large scale as in farm soil additives, and at the small scale as in use for gardens and flower beds. Encourage municipal use of compost instead of peatmoss or other natural resources.

Constraints

At today's rates, the average cost per tonne to compost in Alberta (assuming similar pick-up costs are used) is in all cases higher than the average cost to landfill the same quantity of organics (this assumes no direct financial revenue from the product).

The capital cost to develop the infrastructure for composting is a major constraint since most municipalities are in a cost squeeze and cannot afford to capitalize equipment.

Private compost operations must rely upon ready markets.

Opportunities

Rising landfill costs will make composting more attractive as time goes on.

The closing of local landfills and the incorporation of regional systems is forcing municipalities to reduce volumes of garbage collected and thus the high cost of transportation and tippage fees at regional landfills. Many communities are encouraging residents to reduce volumes of yardwaste through backyard composting. In many cases, municipalities are providing low cost composters and training for interested residents and although involvement (as a percentage of population) has been low, it is expected that many residents will continue with the programs that have been put in place. This form of reduction at source is very cost efficient.

Smaller communities where windrow or static pile systems can be utilized, can operate at lower costs if they utilize current Public Works equipment. Effective composting can take place without the need to incur large capital investments, however, the quantity and quality of compost produced is directly related to the efficiency of the system.

Action / Direction

Encourage municipalities to position themselves for rising landfill costs and to reduce or replace this form of waste removal by placing greater emphasis upon composting and recycling.

Governments at all levels should continue to encourage backyard composting through the provision of information, education and increased awareness of the positive impacts that voluntary composting can have.

If resources permit, financial assistance programs should be directed at:

- capital assistance wherein capital upgrade programs are available to those municipalities who have demonstrated proven success in base level programs (criteria would have to be developed and the respective municipality or group would have to demonstrate a degree of prior investment)
- operational assistance could be provided to municipalities as a means to diversify their waste management practices and to attempt base level programs. These programs should serve to augment needed changes to equipment and/or public level collection services and provide market literature.

All assistance programs should encourage joint municipal or regional participation and opportunities for private and public collaboration.

The onus for development should come from within municipalities and assistance should not be provided without substantial local investment in time and resources.

9.1 Introduction

Across the Province of Alberta, municipalities are facing the prospect of huge increases in the cost of waste disposal as existing dumps near capacity and are forced to close. The administrations recognize the realities of replacing them with environmentally responsible alternatives which meet current standards. Some are seeking a solution under the umbrella of a Regional Waste Management Plan which will group a number of towns together to pool their resources as well as their waste streams. Not all communities fall into compatible and readily manageable regions for this purpose, and for them another solution must be found.

Organic materials make up well over half the waste generated by most communities in the province. Some of these wastes, such as cardboard and old newsprint, are absorbed happily by existing recycling programs - although the economics of such programs can be difficult to justify if the community is not within easy reach of a major recycling centre such as Edmonton, Calgary or Whitecourt. Some are recycled by enthusiastic amateurs, back-yard composters, or diverted for use as garden mulch, cattle feed or bedding material. For perhaps 40% of what remains, composting has shown itself to be a viable waste diversion strategy, returning valuable humic materials and nutrients to the land in a beneficial way that sustains the environment.

Recent studies have shown conclusively that, if approached systematically as an integral part of the waste management process, recycling and composting can reduce the cost of municipal sanitation in communities with populations in the millions and as small as a few hundred.[153]

9.2 The Community

A generic community, called "Smalltown, Alberta" is taken as the basis for this brief desktop study, having a population of the order of 3,000 - 5,000. In real terms Sundre, with a population of 4,220 including the rural areas which depend on its infrastructure, would match this model quite happily. Grande Cache, with a population of 3,885, would serve equally as well to help visualize our concept. The input data, however, represent a synthesis of a number of towns in the province, based on waste audits compiled for actual communities and institutions.

9.2.1 Its Location

Because so much of the population of non-metropolitan Alberta has its livelihood linked to agriculture, we assume a model based on a township of about 3,000 people with an inter-dependent rural community of half this size. It is at a sufficient distance from any city to have its own municipal waste management organization for solid wastes *(MSW)* and a water-treatment facility for liquid wastes. It is more likely to rely on road transport than on rail as its primary means of communication with other communities, although either CP or CN is likely to have a freight terminal linked to the grain, timber or coal industries. Its distance from the larger cities in the province makes economic recycling of many widely recognized recyclables marginally cost-effective at best, possibly a total non-starter in practical terms. It is likely that the further west the town is located, the more difficult it will be to recycle even paper economically; farms are likely to give way to timber-related industries, mining or the resort industries.

9.2.2 Its Composition

The community will have about 1,000 dwellings in its urban centre, composed largely of single family homes but including about 100 each of apartment dwellings and mobile homes. The rural population linked with the urban centre is about 1,500, largely on farms but including some relatively secluded acreages. At least half of the farms will sustain substantial numbers of livestock - cattle, pigs and poultry.

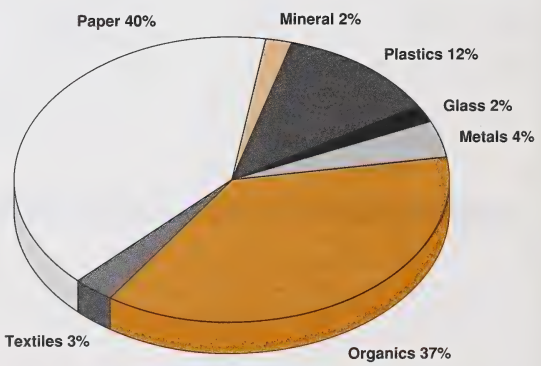
The town will have a hotel or motel, no less than 5 restaurants of one sort or another, retail outlets for meat, groceries, baked goods and general merchandise, a market garden or landscaping centre and a transport depot of some kind. There will be a grain elevator or a timber-processing facility. There will be a tourist attraction of some kind - a rodeo ground, perhaps - a leisure centre and a campground within the municipal area.

9.2.3 Its Solid and Liquid Wastes

Table 9.1 represents, sufficiently accurately for the present purposes, the composition of mixed solid wastes from a predominantly urban community.

The composition chart shows a compostable organic fraction of 77% of the solid wastes produced in the

Figure 22 - Total Waste Stream Composition



Adapted from GCG Dillon, 1990[154]

community. Organic waste audits undertaken within Alberta, suggest that Smalltown, Alberta will generate a total of 2,740 tonnes of compostable wastes each year - which accords very closely with 77% of the 800 kg per person per year widely accepted for garbage of all kinds in Canada.

The range of organic wastes considered is shown in Table 3.2 in Section 3.2.3, where each component of the waste stream is categorized very broadly as a solid or a liquid, carbon-rich or nitrogen-rich, easy to recycle or difficult (and therefore likely to end up in the landfill unless processed differently), and so on. The solid wastes we have considered amount to 1,880 tonnes of carbon-rich and 860 tonnes of nitrogen-rich organic material.[3]

In addition, the water treatment facility is likely to produce some 10 tonnes per year of compostable biosolids by dry measure, extended to 120 m3 of sewage sludge at a moisture content *(M/C)* of about 5%-10%, as it might be recovered from evaporating ponds.

The hinterland surrounding Smalltown is likely to be considerably dependent on farming of one sort or another. Farms often generate large quantities of compostable material, mostly in the form of animal manures and soiled bedding. For purposes of illustration a distance of 30 km from the town is assumed as delineating the area within which this highly desirable material may be economically hauled.[155] Within this radius it is assumed that there will be the mix of agricultural waste generators shown in Table 9.1 below. They will vary in size, but mean figures have been taken from actual audits to calculate the expected waste material quantities. Thus if no more than 20% of the *FYW* can be brought into the composting scheme, by transportation to the site or by composting at one of the farms, the entire program becomes so heavily weighted by the nitrogen-rich animal wastes that the process of composting becomes very simple, once the logistics of transportation have been mastered.

Table 9.1 FYW Generated on Farms within 30 km (tonnes/year)

Generator		Carbon Rich	Nitrogen Rich	Total
Mixed Farms	3	5	3,000	3,005
Dairy Farms	2	83	48*	131
Feed Lots	3	-	27,000	27,000
Poultry	4	12	732	744
TOTAL		*100*	*30,780*	*30,880*

*Note: This is not to be taken as an indication of the C:N ratio, which is found by a much more complex calculation.

*Note: 60%-70% of the whey from cheese-making is used for feeding hogs, the remainder often being spread on the land as a low-grade fertilizer.

Alternatively, if Smalltown, Alberta is surrounded by forestry industries, they are likely to have much more carbon-rich waste material to contribute. Some of this, as shredded wood-chips and bark, will be useful to any composting program as a bulking agent to keep air channels open in the biomass. The quantities we have assumed as potentially available to the urban centre are:

9.3 Current Waste Management Procedures

Most small towns in the province are still operating on a fairly conservative, traditional pattern of solid waste collection and disposal under the auspices of the municipal authority, probably with the participation of a commercial waste haulage contractor, and with a water treatment facility operated and maintained by the municipal engineering department.

Table 9.2 Wood Industry Wastes within 30 km (tonnes/year)

Carbon Rich	Nitrogen Rich	Total
77,000	7,500	84,500

9.3.1 Method of Collection and Transportation

There are two basic sectors from which solid waste is collected and transported to either a landfill, transfer station or recycling station: the Residential sector, and the Industrial, Commercial and Institutional sector *(ICI)*. The methods by which the waste from each sector is collected and transported vary depending on the small town community.

The residential sector waste would be either under contract to a commercial hauler or may be picked up by the municipality. Smalltown is likely to have a service provided to its residents and would not promote individual self hauling. This sector contributes approximately one half of the waste generation within its limits (*i.e.*, excluding the rural area with which it is associated), the other half coming from the *ICI* sector. At present there is very little done to divert waste from the landfill, since markets for recycled materials are distant and transportation costs do not qualify these material wastes for economical recycling. Composting is almost unknown, except in backyards and on farms.

The *ICI* sector, the other half of the waste generation, is not usually incorporated into a municipal solid waste hauling system. Typically a contractor deals with each business on a "user-pay" basis, employing a variety of collection bins and vehicles. The alternative is that the business hauls its own waste to either the landfill or a

transfer station. In either of the above collection systems, a regional approach to collection of *ICI* waste is the most viable. This allows for better concentration, better utilization of equipment and is more cost effective. Currently few small town communities have taken on a major recycling project which would include a sorting facility. For composting purposes, a wet/dry sorting system or any separation-at-source method would be very advantageous, since those materials which will be composted would be separated by the waste generator from the other materials prior to collection. This has been found to produce a superior compost, freer of contaminants that limit its usefulness and range of application.

9.3.2 Cost of Collection and Transportation

In Smalltown, the cost of pick-up by a contractor is taken to be in the $3 - $4 range per resident per month. The residential sector offers a great amount of compostable material in small towns, as transportation costs to markets are high, relating to the distance necessary to transport recyclables to a suitable centre. Private hauling of material *(self-haul)* will always take place in the *ICI* sector, and for many businesses it is the least costly option due to peaks and valleys in production. Others are assumed to use a commercial system on a "user-pay" basis, with dumpsters provided by the contractor and haulage costs at $150 per hour.

9.3.3 Method of Disposal

After collection, solid wastes that are not recycled or composted may be landfilled at a local or regional facility, delivered to a transfer station or incinerated. Landfilling has always been the easiest way to dispose of solid waste, and there are currently "dumps" still in operation which are not up to standard and so are not classified as Sanitary Landfills. For instance, throughout the West Yellowhead region there is an assortment disposal methods. The Hinton Regional landfill is the central landfilling location for the Town of Hinton, Jasper Park and the west part of I.D. #14. The Town of Edson and east I.D. #14 have formed a Regional Waste Management Authority and are in the process of locating a centralized landfill site to replace existing waste disposal sites. The Town of Grande Cache has a local landfill site for their own use.

Similar overall procedures will be in operation at Smalltown and, in evaluating the tables for their content of organic materials of all kinds, it would appear that the opportunities for capturing organic and compostable material are good.

In most cases the landfill costs per tonne usually determine the extent to which other disposal methods have been adopted or attempted. In some ways tipping fee differentials provide an enforcement mechanism for banning particular material from the landfill. A fee differential offers the option of segregating and recycling materials or paying a premium price for disposal.

9.3.4 Cost of Disposal

The costs of disposal are usually no greater than the per capita cost of collection.

Table 9.3 Summary of Waste Quantities Generated[156]

Municipality	Waste Generation Rate (kg/cap/day)	Population (1991)	Waste Generated (tonne/year)
Edson	2.6	7,323	6,900
Entwistle	2.4	460	400
Evansburg	2.4	723	600
Grande Cache	2.4	3,842	3,400
Hinton	2.4	9,046	3,400
TOTAL		21,394	22,600

UMA Engineering Ltd

Table 9.4 Summary of Known Solid Waste Management System Costs 1992 $'s[157]

Municipality	Collection	Disposal	Other	Total
Edson	80,400	70,000	14,000	164,400
Grande Cache	86,750	40,808	3,476	131,034
Hinton	252,240	156,230	18,320	426,790

UMA Engineering Ltd

The current costs of disposal will depend on Smalltown rates applied at the landfill scale, but are typically $10 to $25 per metric tonne. These will inevitably rise as the existing landfills are closed and replaced by more expensive facilities designed and built to far more stringent criteria of environmental responsibility.

9.4 Composting as an Alternate Strategy

The elements of the composting process are described in Section 3, and an outline of useful composting technologies is given in Section 6. Those established principles are here applied to the situation in Smalltown, Alberta.

9.4.1 Quantity of Compostable Materials

If a determined effort is made to compost the organic wastes that would otherwise have been landfilled, a capture-rate of 75% of the waste materials generated within the entire residential, commercial and industrial community is by no means impossible. The present concentration on recycling in the province will probably mean that some of the paper and cardboard is pulled out of the waste stream, or soon will be even in Smalltown. It is therefore assumed that the urban area and surrounding residential property served by the collection scheme will contribute 0.75 x (2/3 of 1,880 + 860) = 1,585 tonnes/year of compostable wastes.

By comparison, virtually unlimited quantities of *FYW* are available within an economical haul distance from the urban centre, which can increase the quantity of biosolids to whatever level is desirable. What is not yet clear is the extent to which farmers will be willing to release their materials for the purpose. Poultry manure is very rich in nitrogen, dry and compact. Much manure from mixed farms, feedlots and dairies is currently spread on the land, where it probably loses 75% of its available nitrogen, the principal nutrient, and contributes large quantities of methane gas to the ozone-depleting greenhouse gases. The comparable benefits of composted manure are well known to some, but a program of education may be necessary to convince traditionally-minded farmers to join the scheme.

9.4.2 Achieving a Compostable Mix

A detailed calculation of the *C:N* ratio of the several identifiable components in the waste stream of Smalltown, Alberta, can be made by reference to Table 3.1 Feedstock Preparation / *C:N* Ratio Control in Section 3.2.1.[158] A ratio of about 35:1 is ideal, and sewage sludge from the water treatment facility, rich as it is in nitrogen, will combine well with the predominantly carbon-rich *MSW* to produce a mix well within the bounds of acceptability for composting to proceed. In large cities there is often a concern about contamination by heavy metals, but this is less likely to be significant in a small town where industries that generate them are less commonly located. A stage of pre-treatment is required to make a good composting medium, of size reduction and homogenization of the several components of the mix and distribution of the bulking agent that will ensure adequate air passages throughout the biomass. Thereafter, producing compost is largely a matter of sound management of a suitable composting process.

9.4.3 Process Options

Supposing that some sewage sludge is added, for its moisture and nitrogen content, and that a modest amount of *FYW* is brought in to enrich the nutrient content of the compost mix, it would seem appropriate to consider a total input 2,000 tonnes per year or thereabouts as the capacity for the composting process. Three broad options are currently available for this quantity of waste materials: windrow composting, with or without aeration, an aerated static pile under cover, and a simple enclosed channel system.

The windrow system has the advantage that it is simple to set up, requires largely agricultural equipment to operate and involves minimal capital. Its principal drawbacks are that it slows down to almost dormant activity during the coldest months of the year, and it is relatively vulnerable to predators.

The aerated static pile works better than windrows under winter conditions, can be accommodated in a simple implement shed provided with an operating surface that protects the groundwater, and still uses agricultural-type equipment. In all other respects it is strictly comparable to windrowing, and is equally vulnerable to pests or predators.

The simple channel system is near the bottom of its cost-effective range at this capacity, but works relatively trouble-free all year round if set up in a suitable agricultural building where the heat generated by the process can be contained.

Either the windrow method or the aerated static pile will probably operate actively (i.e., biologically functional) for no more than 200 days in the year, of which only 150 or so are "working days," giving a daily capacity of about 13 tonnes. The channel system can work adequately year-round, but only 260 days are working days. Its operation capacity has therefore to be sized at about 8 tonnes per day.

9.4.4 Capital Costs Involved

The essential civil works for a windrow composting system include an impervious composting pad approximately 100 ft wide x 320 ft long, a drainage system for liquid runoff to a square storage pond of 40 ft side and 5 ft max depth, and a mixing area made of precast Jersey Barrier units. The essential mechanical equipment is a size-reduction mill of some kind, a front-end loader mounted on a tractor with hydrostatic drive and not less than 60 hp, to which can be coupled the simplest of windrow-turning machines.[159] If the tractor-loader is acquired secondhand (and many are available for about $10,000), the entire capital cost could well be in the region of $150,000.

An aerated static pile system of similar capacity operates beside the Cowansville water treatment plant near Sherbrooke, Quebec. The entire capital cost was of the order of $200,000, including the operating pad, building, mixing and aeration equipment. A small windrow turning machine is used for mixing the materials on a waterproof working surface prior to stacking in the piles, and can be used for periodic re-mixing or aeration if the process stalls for any reason.

The POS channel system is based on modular channels of about 7-10 tonnes per day capacity, so a single channel could accommodate the wastes from residential and *ICI* sectors. The civil works are much reduced and a simple front-end loader or bobcat is adequate for all load transfer operations, after size reduction by a bearcat, a haybuster or some other agricultural grinder. If a significant quantity of *FYW* were introduced to simplify the whole composting process, perhaps doubling the total annual throughput, it would be very easy to construct two channels side by side or arranged end to end, served by one transferable turning machine.

It is likely that site preparation and a suitable building could cost of the order of $100,000 inclusive of electrical power hook-up. The mechanical equipment, both for general and specialized use, could well cost a further $120,000, depending on whether the compost turner was electrically driven or diesel powered. A further $30,000 would cover the aeration equipment and computerized controls, which greatly assist the operation of such a system, making for a capital investment of some $250,000 in all.

These rough estimates all assume that the basic collection and transportation service continues to be operated by the municipality, and only some reorganization is required.

9.4.5 Operating Costs Involved

At a greater degree of delicacy than is warranted in a brief review of this nature, detailed operating costs can be calculated. For the present, known operating costs for similar installations are indicative of what may be expected.

From the point of delivery to the site, costs of a number of windrow composting systems operated by Compost Management Ltd in Ontario all average out at between $30 and $35 per tonne. The covered, aerated static pile operation at Cowansville is now operated at $38 per tonne. A preliminary estimate by CSC Prairies, Saskatoon, put the expected operating cost of channel composting at the Riverbend Institution at between $35 and $40 per tonne.

A modest escalation is recognizable in this range of costs, largely reflecting the amortization of greater capital. In fact the manpower needs decrease with each step in mechanization and it is not likely that any very great difference will be seen overall.

9.4.6 Uses for Compost

Broadly, the uses envisaged for the compost produced at the Smalltown, Alberta facility fall into two categories: agricultural or horticultural, and land re-development. The compost should be sufficiently upgraded and matured to be suited to its ultimate use. For some purposes, such as domestic and market gardens, the product would need to be further refined by passing it through a fine screening plant, reducing the particle size to some 15 mm, which is eminently suitable for packing in plastic sacks for sale in small quantities. In some situations it may be useful if the composition of the refuse is altered in order to improve the quality of the compost obtained, for instance by adding source-segregated wastes.[160]

In agricultural and horticultural use, which may well include tree culture (the largest single use of *MSW* compost in Sweden and in the Pacific northwest of the US), its use as a seeding medium is comparable to that of peat moss and superior to that of many other substances. Compost is particularly attractive for acid soils, where its *pH* tends to correct the low value existing in the soil, and for clayey, sandy and other porous soils, where its humus content breaks up clogged soil structures and retains moisture in otherwise non-retentive granular soils. In addition to its modest nutrient content, which is distinctly superior to that of peat, it thus assists the soil in retaining applied nutrients.[161] Table 5.1 in Section 5.1 shows recommended application rates.

In land development or re-development, a main use of compost is to help vegetation get established on disturbed soils and on soils which lack natural humus. Composts are being used for land reclamation in parks, on sports fields, for road and motorway route embankments, in landscaping programs and in the reclamation of mine and oil well sites.

9.4.7 Funding and Sale of Compost

The capital investment required for each of the schemes outlined is modest. Even so, provided that the proposed project is undertaken by a municipality or by a private developer in cooperation with a municipality, there are a number of funds which may provide some offsetting grants.

i) Environmental Partners Fund, Environment Canada. Created under Canada's Green Plan, this helps fund new community-based environmental projects. A variety of environmental projects are eligible, including recycling and composting activities. Further details are available by contacting Environmental Partners Fund, Environment Canada, #210 4999 - 98 Avenue, Edmonton, Alberta T6B 2X3 (Tel: 468 8931).

ii) ***Friends of the Environment Foundation, Canada Trust.*** Grants are available for establishing environmental projects in communities with branches of Canada Trust. Details are available by contacting the local Canada Trust branch manager or B. Munroe, Edmonton, Alberta (Tel: 441-4500).

iii) ***Municipal Scale Composting Fund,*** Procter & Gamble. Financial assistance is available for establishing municipal composting projects. Details are available by contacting John Bartlett at Procter & Gamble, PO Box 355 Station A, Toronto, Ontario M5W 1C5 (Tel: 416 730 4400).

iv) ***Resource Recovery Grant Program,*** Alberta Environmental Protection, Waste Minimization Branch. The objective of this program is to facilitate the development of recycling and waste reduction projects in municipalities and communities. Projects that involve several communities and target several types of materials are encouraged. Funds are available for capital costs but not operating costs. Several composting projects have been funded. Details are available from the Waste Minimization Branch, Alberta Environmental Protection, 5th Floor, 9820 - 106 Street, Edmonton, Alberta T5K 2J6 (Tel: 427 5838).

v) ***Shell Environmental Fund.*** Established for projects that propose innovative ways of improving and protecting the Canadian environment, the fund assists individuals and organizations such as service clubs, environmental groups and youth groups. The maximum funding is $5,000 per project per year. Details are available from Shell Canada, PO Box 100 Station M, Calgary, Alberta T2P 2H5 (Tel: 800 661 1600 or 691 3198).

No sizeable market has yet been developed for *MSW* or yard waste compost in the province, largely because it has never been produced in any quantity. Some entrepreneurs such as David Thevenaz of Bentley, Alberta having been selling composted steer manure for years, at a price reported to be between $20 and $40 per tonne, considerably more attractive than that secured for the *Greenleaf* product coming from Olds College.[162] Bagged *"Millorganite"*, a soil additive made in the US from sewage sludge, and its BC equivalent, sell in Edmonton for $12 for a 40 lb bag, the equivalent of $665 per tonne.

A recent survey of a number of small farm composting operations mostly in the USA, shows how they have grown as they have prospered, and added further materials to their organic mix rather than declined. Their growth has been a result of sound commercial management rather than dependence on government subsidies. Difficult as it is to predict an Alberta market price, it is not self-evident that composting must operate at zero financial profit. Table 5.3 and the discussion in Section 5.3 show that there are possibilities for a cooperative venture between Smalltown and a private composter, as one possible way of managing the organic waste diversion that is contemplated.

9.5 Synopsis of Costs and Benefits

Given present conditions and the fact that the costs of collection and transportation of organic wastes are a constant component of any scheme for recycling and disposal of urban wastes in separate streams, there is no clear financial advantage to be gained from composting the organics rather than landfilling in facilities at Smalltown. However, as the cost of siting, developing, and operating new landfills increases, and as the full cost of landfilling waste is realized, composting will become an attractive alternative to landfilling, especially in the more densely populated parts of Alberta.

A higher tipping fee at the landfill becomes an incentive to recycle and to compost. Procurement policies encouraging the use of compost as a soil amendment will strenthen the demand side of the compost market.

Other benefits, albeit more difficult to quantify, are those to the environment from returning the spent organic matter in a benign form to the earth from which it came; and expanding on the image of Western Canada as a place of pristine beauty and cleanliness.

What this review demonstrates is the ecological superiority of composting over many more traditional ways of disposing of the same materials in Smalltown, Alberta, which conveys real benefits to the community, to the province and to Canada.

9.6 Conclusion

Composting is a proven technique for diverting the non-recyclable organic content of any urban waste stream. Coupled with a recycling program, it has shown itself to be viable, cost-effective and sustainable in many communities in Europe and North America. In its infancy in Canada, solid waste composting is gaining ground constantly and is the subject of other projects in progress by the Government of Alberta.

Given the historic dependence on landfilling urban wastes through much of Alberta, which is relatively inexpensive to the user, it is difficult to justify composting on the narrow basis of present value bottom line accounting. Taking a broader view and acknowledging current trends in the acknowledging the true costs of waste disposal, this scene is likely to shift into balance or better within a very few years.

Other considerations that seek to place a value, however imprecise, on preserving the ecological balance and protecting the environment, provide a sound non-fiscal argument for composting. The Government of Alberta is responding positively to these considerations. Smalltown, Alberta is probably preparing now for the changes that are coming. A measure of cooperation between the private sector and smaller communities who need help to establish their own composting schemes presents a valuable opportunity to develop excellent community relations, as well as demonstrating a practical concern for the environment.

Further detailed information on all aspects of composting is available through participation in the activities of the Composting Council of Canada and through such publications as BioCycle, The On-Farm Composting Handbook and others, of which a fuller list appears in the

References Cited and Extended Bibliography (contained in the Technical Appendix to this report). Numerous conferences on composting are staged across North America, and several composting operations can be seen in largely urban settings within a reasonable travelling distance of Alberta.[92]

A final statement on the value of composting the organic waste from Smalltown, Alberta is contained in the Editorial from BioCycle Magazine for July 1993, which may be summarized as follows:

> *Thirty years ago William Albrecht, soils professor at the University of Missouri and an outspoken advocate for the role of organic matter in a healthy agricultural system, wrote: "Man is upsetting much of the natural environment by his contamination of the air, the water and particularly the soil, reducing its ability to dispose of wastes safely and to nourish healthy populations ... It is a dangerous boldness to believe that we can manage environments completely by technologies designed for our economic advantage."*
>
> *Research at several major US Universities shows how compost can be used instead to suppress plant diseases, reducing the need for chemical pesticides. Scientists at the University of Kassel in Germany have compared the effects of composts prepared from farmyard manures, kitchen and yard wastes with mineral fertilizers on carrots, potatoes and tomatoes. In Compost Science & Utilization 1993 they report that some composts significantly reduce nitrate levels in crops while increasing the Vitamin C content of vegetables.*[164]

GLOSSARY OF TECHNICAL TERMS AND ABBREVIATIONS

Actinomycete. A group of microorganisms, intermediate between bacteria and true fungi, that usually produce a characteristic branched mycelium and are responsible for the earthy smell of compost. Other microorganisms in compost include **basidiomycetes** and **eumycetes**.

Aeration. The process by which the oxygen-deficient air in compost is replaced by air from the atmosphere. Aeration can be enhanced by turning the compost, by passive aeration or by forced aeration using blowers.

Aerobic. An adjective describing an organism or process that requires oxygen (*e.g.,* an aerobic organism, aerobic decomposition).

AgCan. Agriculture Canada.

Ambient conditions. The temperature, relative humidity, gas mix and other qualities of the air in the vicinity of the compost pile.

Ammonia (NH_3). A gaseous compound comprised of nitrogen and hydrogen. Ammonia, which has a pungent odour, is commonly formed from organic nitrogen compounds during anaerobic digestion.

Anaerobic. An adjective describing an organism or process that does not require air or free oxygen (*e.g.,* anaerobic digestion).

Aspergillus fumigatus. Species of fungus with spores that cause allergic reactions in some individuals. It can also cause complications for people with certain existing health problems.

Availability. The degree to which a commodity or material is free to be taken into the process or system, usually less than the total that can be measured as occurring (*e.g.,* available nitrogen, available as feedstock).

Bacillus (plural **bacilli**). Rod-shaped aerobic bacteria which form spores, often occurring in chains and including *b. anthracis*, the cause of anthrax.

Bacteria. A group of microorganisms having single-celled or noncellular bodies. Bacteria usually appear as spheroid, rod-like, or curved entities but occasionally appear as sheets, chains, or branched filaments.

Bedding. Dry absorbent materials used to provided a dry lying surface for livestock. Bedding materials such as sawdust and straw absorb moisture from livestock wastes, the soil and the environment.

Biodegradation. The breaking down of organic matter that occurs in nature or in accelerated natural processes such as composting.

Biomass. The collected organic ingredients in a process, more or less homogenized and subjected to the process or treatment as a whole.

Bucket loader. A vehicle which employs a hydraulically operated bucket to lift materials. Includes farm tractors with bucket attachments, skid loaders and large front-end loaders.

Bulking agent. An ingredient in a mixture of composting raw materials included to improve the structure and porosity of the mix. Bulking agents are usually rigid and dry and often have large particles (*e.g.,* straw or wood chips). The terms "bulking agents" and "amendment" are commonly used interchangeably.

C:N. Carbon-to-nitrogen ratio.

Capture rate. The degree to which a commodity or materials can be brought together for use in a process or system, often expressed as a percentage which is usually less than 100%. See also **availability**.

Carbon dioxide (CO_2). An inorganic gaseous compound comprised of carbon and oxygen. Carbon dioxide is produced by the oxidation of organic carbon compounds during composting.

Carbon-to-nitrogen ratio. The ratio of the weight of organic carbon (C) to that of total nitrogen (N) in an organic material.

CCME. Canadian Council of Ministers of the Environment.

Cellulose. A long chain of tightly bound sugar molecules that constitutes the chief part of the cell walls of plants.

Channel composting. A diverse group of composting methods in which composting materials are contained between the walls of an open-topped channel and are subject to periodic turning to improve their aeration.

Colonization. The process by which fungi or microorganisms multiply and spread rapidly through a medium, as in a compost pile when the conditions are favourable.

Comingled wastes. Waste materials that are mixed together (or have not been separated) and thus have the possibility of cross-contamination between different components.

Co-composting. Composting two or more distinctly different materials together, generally as a stratagem for achieving a better balance of carbon and nitrogen, or a favourable moisture content. Usually refers to the composting of solid wastes, which are relatively dry and carbon-rich, with wet sewage sludge which is rich in nitrogen.

Compost. A group of organic residues or a mixture of organic residues and soil that have been piled, moistened and allowed to undergo aerobic biological decomposition.

Composting. Biological degradation of organic matter under aerobic conditions to a relatively stable humus-like material called compost.

Contaminant. Any matter or organism which is introduced into the medium or environment causing contamination.

Contamination. Any introduction into the environment (water, air or soil) of micro-organisms, chemicals, wastes or wastewater in a concentration that makes the environment unfit for its intended use.

CSC. Correction Services of Canada.

Cubic yard. A unit of measure equivalent to 27 cubic feet, about 0.76 cubic metres. A cubic yard is often loosely referred to as a "yard" (*e.g.*, a one-yard bucket).

Curing. Final stage of composting in which stabilization of the compost continues but the rate of decomposition has slowed to a point where turning or forced aeration is no longer necessary. Curing generally occurs at lower, mesophilic temperatures. Used synonymously with maturing.

Degradability. Term describing the ease and extent that a substance is decomposed by the composting process. Materials which break down quickly and/or completely during the time frame of composting are highly degradable. Materials which resist biological decomposition are poorly or even non-degradable.

Digestion. The breaking down of organic matter which occurs in moist, anaerobic conditions, as in the stomach of an animal or in a specially constructed vessel. Digestion typically releases biogas, a mixture of methane and carbon dioxide which can be burned as a fuel.

EPA. The Environmental Protection Agency of the United States.

Feedstock. Material that becomes a component of a treatment or manufacturing process. In this context, largely waste materials that are diverted from other means of disposal to become the components of a composting process.

Fertilizer value. An estimate of the value of commercial fertilizer elements (N,P,K) that can be replaced by manure or organic waste material. Usually expressed as dollars per tonne of manure or quantity of nutrients per tonne of manure.

Footprint. The area of land occupied by a building or other construction.

Forced aeration. Means of supplying air to a composting pile or vessel which relies on blowers to move air through the composting materials.

Fungus (plural **fungi**). A group of simple plants that lacks a photosynthetic pigment. The individual cells have a nucleus surrounded by a membrane, and they may be linked together in long filaments called hyphae. The individual hyphae can grow together to form a visible body.

FYW. Farm yard wastes. Sometimes referred to as livestock waste. This material may also contain bedding, spilled food, water or soil. It may also include wastes not associated with livestock excreta, such as milking centre wastewater, contaminated milk, hair, feather or other debris from farm operations.

Green waste. Plant material which may be incorporated into the soil, while green, to improve soil or incorporated into some other soil amendment program such as composting.

Heavy metals. A group of metallic elements that include lead, cadmium, zinc, copper, mercury and nickel. They occur in small quantities in all soils and can be found in considerable concentrations in sewage sludge and several other waste materials. High concentrations in the soil can lead to toxic effects in plants and animals ingesting the plants and soil particles. Federal and provincial regulations restrict the land applications of materials which contain high concentrations of heavy metals.

Holding pond (also called retention pond or runoff pond). An earthen basin to temporarily store precipitation runoff and other water for later use or disposal. Holding ponds can be excavated or formed above grade by constructing earthen embankments.

Humus, humic materials. The dark or black carbon-rich, relatively stable residue resulting from the decomposition of organic matter.

ICI. Industrial, Commercial and Institutional sources of waste materials.

Incineration. The disposal of waste materials by burning at high temperatures, usually in a large centralized facility which may produce power from the waste heat.

Interstitial oxygen. The oxygen, usually derived from the air, which percolates through the spaces in a biomass and allows the microorganisms to perform various aerobic functions.

In-vessel composting. A diverse group of composting methods in which composting materials are contained in a building, reactor or vessel.

Keratin. A tough insoluble protein substance that is the chief structural constituent of nails, hair, horns and hooves.

Landfilling. Disposal of waste material in excavations and/or landfills. Varying degrees of rigour are imposed on the ability of landfills to contain the material without escape of leachate into the surrounding soil and groundwater, or gases and offensive odour into the atmosphere, governed by provincial regulations according to the classification of material landfilled.

Leachate. The liquid that results when water comes in contact with a solid and extracts material, either dissolved or suspended, from the solid.

Lignin. A substance that, together with cellulose, forms the woody cell walls of plants and the cementing material between them. Lignin is resistant to decomposition.

M/C. Moisture content.

Master Composter. A person specially skilled in composting, usually in backyard composting in the home, who teaches others the techniques of composting through some municipally organized program.

Maturation. See **curing**.

MD. Municipal District.

Mesophilic. Operationally, the mid temperature range most conducive to the maintenance of optimum digestion by mesophilic bacteria, generally accepted as between 10° and 40°C (50° and 105°F).

Metabolism. The physical and chemical action by which some substances are broken down inside a living cell or organism to yield energy for the vital processes, while other substances necessary for life are synthesized.

Microorganism. A living organism so small that it requires magnification before it can be seen.

Moisture content. The fraction or percentage of a moist substance that is water. Moisture content equals the weight of the water portion divided by the total weight (water plus dry matter portion). Moisture content is sometimes reported on a dry basis. Drybasis moisture content equals the weight of the water divided by the weight of the dry matter.

Mort. Dead livestock from an intensive farming operation, usually referred to fish, poultry or other animals who perish in captivity and must be disposed of.

MSW. Municipal solid waste.

Manure-spreading. Application of manure, sewage sludge, municipal wastewater and industrial wastes onto the land, either for ultimate disposal or for reuse of the nutrients and organic matter for their fertilizer value.

Negative feedback. The physical process whereby a change of state in a material or process gives rise to conditions which tend to reverse the change or restore it to a state of balance.

NIMBY syndrome. "Not In My Back Yard." The widespread aversion of people to have some building, process or operation sited close to them or their property.

Nutrient availability. The relative proportion of a nutrient in the soil that can be absorbed and assimilated by growing plants.

N,P,K. A common combination of fertilizer nutrients, the chemical symbols for Nitrogen, Phosphorus and Potassium.

OCC. Old corrugated cardboard.

Organic matter. Chemical substances of animal or vegetable origin, consisting of hydrocarbons and their derivatives.

Pasteurization. The process by which organic matter can be cleansed of harmful bacteria by heat-treatment.

Pathogen. Any organism capable of producing disease or infection. Often found in waste material, most pathogens are killed by the high temperatures of the composting process.

Paunch slurries. The mixture of undigested food and faecal matter washed out of the intestines of slaughtered animals in the process of preparing the carcass for transportation or butchery.

PCBs. Polychlorinated biphenyls. Persistent, immobile contaminants found in industrial waste and sewage sludge. Federal and provincial regulations restrict the land application of materials which contain high concentrations of PCBs.

pH. A measure of acidity, the concentration of hydrogen ions in a solution. pH is expressed as a negative exponent. Thus, something that has a pH of 8 has ten times fewer hydrogen ions than something with a pH of 7. The lower the pH, the more hydrogen ions present, and the more acidic the material is. The higher the pH, the fewer hydrogen ions present, and the more basic it is. A pH of 7 is considered neutral.

Phytotoxic. An adjective describing a substance that has a toxic effect on plants. Immature or anaerobic compost may contain acids or alcohols that can harm seedlings or sensitive plants.

Pilot program. A scaled-down version of a planned program designed to test the operation on a sample of the material or of the population involved, as a means of verifying numerical data or other assumptions used in the system design before committing greater resources to the full-scale operation.

Pre-treatment. Physical or chemical conditioning of feedstock to make it more easily treated by the process. In composting, this generally includes some measure of separating out unwanted materials, size reduction, mixing and adjustment of the moisture content.

Press-cake. The relatively solid mass remaining after liquids have been expressed from a moist material, such as fruit or sewage sludge.

PTO. Power take off. Drive shaft and coupling on a tractor which transmits power from the tractor engine to implements and secondary equipment (*e.g.*, pumps, grinders and windrow turners).

Putrescible. The ability of organic matter to rot or decompose. This may be in a desired way, as in aerobic composting or anaerobic digestion, or it may be in an undesirable way when conditions favourable to decomposition develop at an unwanted time or place.

Sanitation, of compost. The process by which the biomass that forms compost is cleansed of chemical and biological contaminants or, to a lesser degree, has their activity reduced to the point that they no longer pose a hazard to life or the environment.

Self-haul. Delivery of waste materials to the landfill, treatment facility or some intermediate transfer point by the waste generator, as distinct from having them collected by the municipality or a contractor.

Sewage sludge. Solid portion of waste from sewage treatment plants. Contains human wastes and is relatively rich in nitrogen and numerous other trace elements.

Sharps. The collective name for glass and metal medical waste materials that have a sharp edge or point such as used scalpels or syringe needles that may pose a hazard to operators of the waste collection or treatment facility.

Soil conditioner. A soil additive that stabilizes the soil, improves its resistance to erosion, increases its permeability to air and water, improves its texture and the resistance of its surface to crusting, makes it easier to cultivate or otherwise improves its quality.

Source separation. Separation of the waste materials into two or more distinct components prior to collection to limit the possible contamination of one material stream by the other. See also **wet/dry**, 2-stream, 3-stream systems.

Stability of compost. The reduced rate of change or decomposition of compost as it approaches maturity. Usually stability refers to the lack of change or resistance to change. A stable compost continues to decompose at a very slow rate and has a low oxygen demand.

Static pile. A well-defined heap of compostable materials so formed as to promote the aerobic decomposition of the organic matter. It may have some system of aeration built into it, either passive aeration relying on the stack effect of the heat generated to draw air upwards through the pile, or forced aeration using blowers.

Superwood. A wood substitute manufactured from mixed recycled waste plastics extruded under pressure into poles, planks or other shapes.

Thermophilic. Heat-loving microorganisms that thrive in and generate temperatures above 40°C (105°F).

Tipping fees. Fees charged at the point of reception for treating, handling, and/or disposing of waste materials.

ton. The American "short ton" of 2000 lbs equivalent to about 910 kg. (Ton is also used for the "imperial ton" of 2240 lbs, but not in this document).

tonne. The metric measure of 1000 kg, closely equivalent to the imperial ton.

tpd. Tonnes per day (also used for tons per day).

Tunnel reactor. A totally enclosed composting vessel, usually of rectangular cross section, in which a controlled atmosphere is maintained to promote aerobic decomposition. Tunnel reactors are either "batch loaded," in which case the biomass remains in one place in the reactor until the process is complete, or "slug loaded," in which case a new charge is added periodically at one end of the tunnel and thereby the composted material is forced from the other end of the tunnel.

Turning. A composting operation which mixes and agitates material in a windrow pile or vessel. Its main aeration effect is to increase the porosity of the windrow to enhance passive aeration. It can be accomplished with bucket loaders or specially designed turning machines.

US, USA. The United States of America. Thus US$ is used to distinguish sums quoted in American currency.

User-pay. A system of charging for the waste disposal service based on some parameter of the service provided, such as the weight or volume of materials removed or the frequency of collection, as distinct from a flat-rate service which is incorporated into the spread of municipal charges levied on householders or businesses.

Vector. A mobile carrier of contamination or pollution, or the mobile pollutant itself, such as flies or wind-borne spores.

VOCs. Volatile organic compounds. See **volatile compound**.

Volatile compound. A compound or substance which vaporizes ("evaporates") at relatively low temperatures or is readily converted into a gaseous by-product. Examples include alcohols and ammonia. Volatile compounds are easily lost from the environment of a composting pile.

Waste diversion potential. The capacity to divert a waste material or materials from ultimate disposal by landfilling or incineration, by employing the hierarchy of *Rs -Reduce, Reuse, Recycle.* Incineration in a waste-to-energy plant is usually classed as *Recovery*, the 4th R, and is still a means of waste diversion.

Wet/dry collection. A 2-stream system of source separation whereby the recyclable materials are placed in one container, forming the "dry" waste stream, and other materials are put in a second container. This second, "wet" stream, is often either landfilled or further treated to remove the compostable material from the ultimate remnant which is landfilled. Note that in a 3-stream collection system the recyclable and compostable materials are both separated at source from what is considered to be garbage to be landfilled.

WHO. The World Health Organization.

Windrow. A long, relatively narrow and low pile. Windrows have a large exposed surface area which encourages passive aeration and drying.

Worm composting. A form of composting that utilizes the ability of particular kinds of worms to digest the organic wastes and reduce them to a hygienic worm cast which can be used as compost. This method is temperature sensitive and, although in some climates it is used on a large scale for all kinds of organic wastes, in Canada is largely restricted to small-scale indoor composting.

Yard. See **cubic yard**.

Yard waste. Leaves, grass clippings, yard trimmings and other organic garden debris.

YIMBY. "Yes, In My Back Yard," the positive alternative to **NIMBY**.

YMCA. Young Men's Christian Association.

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(11) **Source Reduction Through Home Composting**, Doron Amiran & Steven E Sherman, BioCycle, April 1992, Page 97(3).

(12) **Composting Task Force Report**, Grocery Industry Committee on Solid Waste, October 24, 1991.

(13) **Composting Biosolids Saves $3.3 Million in Landfill Costs**, Allen R Beers and Thomas J Getz, BioCycle, May 1992, Page 42(3).

(14) **Successful Composting: It Can Be Done**, Chuck Davis and Finley Tyree, MSW Management, January/February 1993.

(15) **The Waste Diversion Potential of Backyard Composting**, Robert J P Gale (University of Toronto), J Env Systems, V20(3), 1990-91, Pages 257(11).

(16) **Composting: Its Role in Industrial Solid Waste Management, Final Report**, Donald Mallet and Charles Bourque, Environmental Sciences Research Centre, Université de Moncton, 1992.

(17) **R T Haig Compost Engineering: Principles and Practice**, Ann Arbor Science Publishers, Ann Arbor, Michigan, 1980.

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(18) **Preparation of a Solid Waste Management Plan for CSC/DND Institutions in the Kingston Area Final Report: Phase II Development of Waste Collection and Prototype Composting Operations**, WCI Waste Conversion Inc, May 1992.

(19) **On-Farm Demonstration Program: Economics of Manure Composting in Southern Alberta, Final Report**, Michael Clawson, Agriculture Research Council of Alberta, November 1989.

(20) **Solving a Dilemma: Landscapers in Northeast Ohio Learn that Composting Saves Money and Improves Their Product**, Rod Tyler, Recycling Today (M M), February 1992, Page 70(5).

(21) **How Compost Fertilization Affects Soil Nitrogen and Crop Yield**, Marc Buchanan and Stephen R Gliessman, BioCycle, December 1991, Page 72(5).

(22) **Code of Agricultural Practice for Waste Management, April 1, 1992**, British Columbia Ministry of Environment, Queen's Printer's, Victoria, 1992.

(23) **Monitoring and Evaluating Composting Process Performance**, M S Finstein, F C Miller, P F Strom, Journal of Water Pollution Control Fed., 1986.

(24) A note recently received from Denmark, where ecological concerns are given high priority, says that the quantity of mercury in batteries is now so small that it is no longer considered a risk, and their widely acclaimed battery drop-off schemes are to be phased out.

(25) Personal communication from Mr K Sawatzky, City of Edmonton Drainage Branch.

(26) **Sludge Compost "Binds" Lead in Contaminated Soil**, BioCycle, October 1991, Page 82.

(27) **Potential Emissions of Synthetic VOCs from MSW Composting**, J C Kissel, C L Henry and R B Harrison, BioCycle, February 1993, Page 77.

(28) In his study **Pathogenic Fungi Associated with Land Application of Sludge**, WHO Regional Office for Europe, January 1981, M D Bertoldi points out that of all the pathogenic fungi that may be part of the composting process *A. fumigatus* alone is not necessarily killed at the thermophilic temperatures attained in most systems.

(29) **Potential Human Health Concerns from Composting: The Aspergillus Fumigatus Debate**, M C Maritato, E R Algeo and R E Keenan, BioCycle, December 1992, Page 70(3).

(30) **Composting of Municipal Trash, Sludge, Yard Waste Poses Negligible Health Risk, Study Indicates**, BNA Environmental Reporter: Current Developments, 28 August 1992.

(31) Manufacturers of totally enclosed tunnel composters working on the batch principle, such as Stinnes Enerco in Toronto and Double T in Airdrie, claim a degree of odour control well above the average of most enclosed vessels.

(32) **Composting Does Not Create Rat Problems**, Gareth Kirkby, Ontario Recycling Update, January/March 1993.

(33) **Composting and Health: A Review**, Nelson Fok (Assoc Director, Environmental Health), Edmonton Board of Health Report, 18 February 1993.

(34) **Environmental Impact of Yard Waste Composting**, T Richards and M Chadsey, BioCycle, April 1990, Page 42(5).

(35) **Sampling/Testing Study of Cedar Grove Yard Waste Compost: Executive Study**, G Zarker and D Gale, City of Seattle Solid Waste Utility, February 1991.

(36) Such as, for instance, Rouville Paper's brown paper bags and Novon Corporation's recently demonstrated 100% biodegradable clear plastic bags.

(37) **Source Separation and Composting of Organic Municipal Solid Waste**, Mark Gould, Richard Garrison and Stephen Foster, Resource Recycling, july 1992, Page 36(6).

(38) **First Year with Wet/Dry Composting (The): A Report from the Field**, Paul Taylor, Resource Recycling, January 1993, Page 34.

(39) **Diaper Composting Experiment Meets with Failure**, Recycling Canada, March 1993, Page 3.

(40) P Blanchard of Canada Composting Inc of Ontario, in a lecture delivered to the 3rd Annual Meeting of the Canadian Composting Council in Montreal, September 1993.

(41) **Correction Service Canada Bowden Waste Management and Composting Stage II**, CMG Engineering Services, March 1993.

(42) Personal communication from Dr Maarten van der Kamp and Sumner Martinson of the Department of Environmental Protection, The Commonwealth of Massachusetts, at the BioCycle Conference in Portland, Maine, September 1993, and from representatives of the governments of Prince Edward Island, Quebec and British Columbia at the CCC Conference in Montreal, September 1993.

(43) **The C/N Ratio and Other Interesting Mixes**, Dr Iain F Clayre, Composting: Everyone's Solution Proceedings of the 3rd Annual Meeting of The Composting Council of Canada, Montreal, September 1993.

(44) Private communication from Hensall Composting Plant in Ontario.

(45) *op. cit.* Clawson, November 1989. (Ref: 19)

(46) **Economic benefits of Recycling (The)**, Brenda A Platt and David Morris, Institute for Local Self-Reliance, Washington, DC, January 1993.

(47) **Privatized Composting in a Farm Setting**, John Bye, BioCycle, October 1991, Page 60.

(48) **Private Company Wants Public Yard Waste**, David Riggle, BioCycle, September 1991, page 41.

(49) Private communication from Berta Dear of the Alberta Greenhouse Growers Association, Lethbridge.

(50) Mr Roger Wood composts 40,000 yd^3 of steer manure each year using simple windrows and a tractor-powered ***Sittler*** turner, at Nampa Farms not far from Boise, Idaho.

(51) **High Altitude Sludge Composting**, William H Smith, Zachary P Margolis, and Brian A Janonis, BioCycle, August 1992, Page 68(4).

(52) **Food Waste Composting Facility Plants Recycling Seeds**, Robert Spencer, BioCycle, April 1991, Page 42(3).

(53) Mr Paul Taylor, a director of the Composting Council of Canada, operates 11 sites in Ontario as Compost Management Inc. composting food and yard wastes in the open.

(54) *op. cit.* Davis and Tyree, 1993. (Ref: 14)

(55) List of MSW Composting Sites using the operating system of DANO of Zürich, Switzerland.

(56) Mr David Thevenaz, Cattle Canada Ltd, who sells bagged steer manure compost under the name "**Alberta Brand Composted Steer Manure**."

(57) **Database on Composting Facilities (A): A Progress Report**, Adam Blackwell and Alicia Neering, Resource Recycling, December 1992, Page 54(5).

(58) **Compost Supply and Demand**, Ann R Buhr, Thomas McClure, Donald C Slivka and Ron Albrecht, BioCycle, January 1993, Page 54(5).

(59) **Potential US Applications for Compost**, Donald C Slivka, Thomas A McClure, Ann R Buhr, and Ron Albrecht, The Composting Council, Alexandria, Virginia, August 1992. (the Battelle Study)

(60) **Beyond 40 Percent: Record-Setting Recycling and Composting Programs**, B Platt, C Doherty, A C Broughton, and D Morris, Institute for Local Self-Reliance, Washington, DC, 1991.

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(63) **Sustainable Farming**, Roger Samson (Publisher/Editor), Resource Efficient Agricultural Production, Ste Anne de Bellevue, PQ, Winter 1992.

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(67) **Gaining Public Support by Design**, Kevin C Skibiski, BioCycle, August 1992, Page 60.

(68) Report delivered to a side meeting of the Maine Chapter of the ACA during the BioCycle Conference in Portland Maine, September 1993.

(69) Dr Peter Meyboom, Chairman of the Composting Council of Canada, in the opening address to the CCC 3rd Annual Meeting in Montreal, September 1993.

(70) **Our Common Heritage**, Report by the World Commission on Environment and Development, United Nations, New York, 1987.

(71) Waste Minimization Branch, Alberta Environmental Protection, 1993.

(72) **Education Programs from a Compost Demonstration Garden**, Beverly Weber (Compost Program Officer, GVRD, Burnaby, BC), Proceedings of The Composting Council of Canada, 2nd Annual Meeting, Ottawa, Ontario, November 5 & 6, 1992, Page 33(8).

(73) **Backyard Composting, 3rd Edition**, The Regional Municipality of Hamilton-Wentworth, Department of Environmental Services - Waste Management Division, Hamilton, Ontario, January 1992, Appendix 2, Page 2.

(74) **Composting Yard and Food Waste at the University of Calgary: An Action Plan**, A Master's Degree Project submitted to the Faculty of Environmental Design, the University of Calgary, in partial fulfillment of the requirements for the degree of Master of Environmental Design (Environmental Science), K H Margaretha Burnett, January 1991, Page 59.

(75) Installed in 1992 under the Ontario Government's Green Workplace Program.

(76) Scott's Composting Farm Inc. Picture by courtesy of Canadian Portland Cement Association, whose roller compacted concrete is used in the construction.

(77) *op. cit.* Otten and Gibson, May 1993. (Ref: 65)

(78) **Correction Services Canada Bowden Waste Management and Composting, Stage I, II and III Reports**, CMG Engineering Services, Edmonton, Alberta, February, March and April 1993 respectively.

(79) Dr Robert G Diener, PEng, Professor of Resource Management, West Virginia University.

(80) **Fisheries Waste to Fisheries By-product, A Composting System Developed for BC's Fisheries Sector**, Niels Holbek (UBC Research Farm, Campbell River) and Brian Egan (Pacific Bio-Waste Recovery Society, Campbell River), Proceedings of 2nd Annual Meeting of The Composting Council of Canada, Ottawa, November 5 & 6, 1992, Page 463(6).

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(82) **City of Guelph Wet/Dry Recycling Program Description**, Waste Management, City of Guelph, May 1993.

(83) **City of Guelph Wet/Dry Pilot Project: Summary of Preliminary Findings**, Waste Management/Recycling, City of Guelph, April 1991.

(84) **The First Year with Wet/Dry: A Report from the Field**, Paul Taylor (Compost Management, Elora, Ontario), Proceedings of 2nd Annual Composting Council Meeting, Ottawa, Ontario, November 5 & 6, 1992, Page 73.

(85) Cowansville, PQ sludge treatment plant operated by Larry Perry, Valoraction, in Sherbrooke, Quebec.

(86) **Process Design Manual for Sludge Treatment and Disposal**, US Environmental Protection Agency Publication #625/1-79-011, EPA, Municipal Environmental Research Laboratory, Office of Research and Development, September 1979, Chapter 12: Composting, Page 12-1(60).

(87) **Small Communities, Small Scale Composting**, Mark Wagner and John Cameron, BioCycle, December 1992, Page 60(2).

(88) Double T Equipment of Airdrie, Alberta.

(89) **Preparation of a Solid Waste Management Plan for CSC/DND Institutions in the Kingston Area, Final Report: Phase II Development of Waste Collection and Prototype Composting Operations**, WCI Waste Conversion Inc, May 1992.

(90) *op. cit.* Otten and Gibson, may 1993, Page ON4. (Ref: 65)

(91) **Correction Services Canada Riverbend Waste Management and Composting Stage II Report**, CMG Engineering Services, March 1993.

(92) **Improving the System for Food Waste Recycling**, Dale S Scott, BioCycle, January 1992, Page 37.

(93) Maintaining the organic mix for 72 hours at the elevated temperature developed in composting has been found by the EPA to effectively pasteurize the biomass, killing off weed seeds, salmonella and other pathogens, It has been widely adopted as a performance requirement, and adopted by the Enviro Choice specifiers, among others.

(94) Variously named "Agrovital" and "Agrenu," such a process is

performing well in Cincinnati in municipal trials, according to personal communication from the City Engineer Boyd Riley, PEng.

(95) **Composts from Papermill Wastes**, Calvin Chong and Robert A Cline (Ministry of Agriculture and Food, Horticultural Research Institute of Ontario Vineland Station), Landscape Trades, October 1991, Page 8(4).

Container Production at Greenleaf Nursery, Calvin Chong (Horticultural Research Institute of Ontario), Horticulture Review, October 1, 1989, Page 8(4).

Effects of Fabric Containers, Dr Calvin Chong, Dr Glen P Lumis and Dr R A Cline, American Nurseryman, December 1, 1989, Page 51(4).

Fabric-grown Trees a Bit Hit at Ravenbrook Farms, Calvin chong and Bob Hamersma (Horticultural Research Institute of Ontario), Landscape Trades, September 1992, Page 33(4).

In-ground Container Production Accelerates Tree Growth, Christine Murray and Glen Lumis (Department of Horticultural Science, University of Guelph) and Calvin Chong (Horticultural Research Institute of Ontario), The Grower, March 14, 1993.

In-ground Container Production of Shade Trees, Christine Murray and Glen Lumis (University of Guelph), Landscape Trades, May 1992, Page 24.

Landscape Ontario Growers' Group Summer Tour - Niagara Peninsula, Christoph Kessel, Calvin Chong and Bob Hamersma, Horticulture Review, October 1, 1992, Page 6(4).

Nursery Research at Vineland: 1992 Update, Calvin Chong and Bob Hamersma (Horticultural Research Institute of Ontario), Horticulture Review, February 1993, Page 15(2).

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Recycling Spent Mushroom Compost in Growing Media, Calvin Chong (Horticultural Research Institute of Ontario), Landscape Trades, March 1991, Page 6(3).

Revolutionary Oklahoma Technique Produces Shade Trees in Two Years, Calvin Chong (Horticultural Research Institute of Ontario) and Hannah Mathers (Alberta Special Crops and Horticultural Research Centre, Brooks), Horticulture Review, October 15, 1989, Page 8(3).

Shade Tress Growth and Nutritional Status as Influenced by Fabric Container and Trickle Fertigation, Calvin Chong, Glen P Lumis and Robert A Cline (Horticultural Research Institute of Ontario and University of Guelph), J Environ Hort, December 1991, Page 187(5).

Shade Tree Production in Above Ground Basket Containers, Calvin Chong and Bob Hamersma (Horticultural Research Institute of Ontario) and Peter Braun (Braun Nurseries), Landscape Trades, October 1990, Page 10(5).

Trickle Irrigation: Wave of the Future, Calvin Chong (Horticultural Research Institute of Ontario), Horticulture Review, January 1990, Page 26(2).

(96) *op. cit.* Otten and Gibson, May 1993, Page BC2. (Ref: 65)

(97) Private communication with Mr Sadler, who services a group of greenhouse growers in southern Alberta, and with Mr Wood as referenced earlier.

(98) No backyard composting is permitted within the National Parks, to avoid invasion of the residential property by bears. Personal communication from Ms Cathy Calvert, Parks, Canada, Jasper National Park.

(99) Technical data received from **Agrovital** in Cincinnati, Ohio, November 1989.

(100) *e.g.* the ***VAM*** system in Holland, and the ***Leeds*** system described elsewhere in this Section.

(101) Dr Sukhur P Mathur's work with Agriculture Canada illustrates a number of innovative ways of handling a wide variety of otherwise unpleasant wastes in windrow composting.

(102) op. cit. EPA, September 1979 and subsequent editions, Chapter 12. (Ref: 86)

(103) Alberta Public Health Act, Waste Management Regulation. AR 250/85, S.39

(104) op. cit. CMG Engineering, Riverbend, 1993. (Ref: 91)

(105) op. cit. Clayre, Montreal, September 1993. (Ref: 43)

(106) The methane gas NH_4 given off by manure rotting in an open field is 27 times as harmful to the ozone layer as the carbon dioxide CO_2 emitted by the same quantity of manure in a well-managed composting process. Also, the nitrogen is not leached out. Similar concerns about excess nitrates in the soil coming from manure have caused the Government of the Netherlands to strictly limit the number of cattle that may be kept on a given area of land, and favour composting manures rather than manure spreading.

(107) *op. cit.* Platt and Morris, January 1993. (Ref: 46)

(108) Greenleaf Products Inc. at Olds, Cattle Canada Ltd. at Bentley, cited elsewhere in this Study.

(109) Private communication from a numbered Alberta company, which would prefer not to be identified at present.

(110) The proposals of TransAlta Utilities and Central Western Railway Corporation, though not yet made public in detail, are a matter of open civic discussion in late 1993.

(111) *op. cit.* Slivka, McClure, Buhr and Albrecht, August 1992. (Ref: 59)

(112) Personal communication with Mr Larry Arvay, Waste Management Technician, Olds College Farm, staff member in charge of composting.

(113) *op. cit.* Fok, February 1993. (Ref: 33)

(114) Membership of the Composting Council of Canada, for example, has representation from every province, from federal, provincial and municipal administrations, from makers of equipment and operators of composting plants, from universities and consultants in the private sector, as well as private enthusiasts.

(115) CBC Television "Venture" business review, 22nd August 1993.

(116) **State of Garbage in America Part II (The)**, Jim Glenn and David Riggle, BioCycle, May 1991, Page 30(6).

(117) *op. cit.* Platt, Doherty, Broughton and Morris, 1991, Page 15. (Ref: 60)

(118) *ibid.* Page 7.

(119) *ibid.* Page 31.

(120) Memorandum: **Waste Minimization Demonstration Pilot Project (Compost) Project, 1992 Project Interim Status Report**, Procter & Redfern, Keir Consultants & First Consulting Group, June 1993, private communication.

(121) **Yard Waste Initiatives Update, City of Waterloo Report PW/WS90-08**, Susan Suave, BES, Dept of Public Works/Operations, City of Waterloo, April 1992.

(122) **Backyard Composting: The First Step in Organic Waste Management**, Cheryl Nash, Resource Recycling, May 1992, page 73.

(123) **Home Composting Programs Reach Out**, JMG, BioCycle, January 1993, Pages 34-36.

(124) **ibid.** Page 34

(125) *op. cit.* Nash, May 1992, Page 80. (Ref: 123)

(126) **Yard Waste as a Mandated Resource**, Jim Glenn, BioCycle, September 1991, page 30

(127) *Western Recycling Systems* was set up to recycle used tires to make rubber mats, conveyor belts and other marketable products, as a recycling alternative to incineration.

(128) Private communication from the management of Wright County and St Cloud compost facilities, to the north of Minneapolis-St Paul, Minnesota.

(129) *op. cit.* Procter & Redfern *et. al.* June 1993, Page 17. (Ref: 121)

(130) **King County, Washington's Master Recycler Composter program**, Cynthia Putnam & Howard Stenn, Resource Recycling, December 1990, page 24

(131) **City Farmer Compost Research, Answers to Questions Received by the Compost HotLine (604) 736 2250**, Gillian Elcock, City Farmer, Vancouver Compost Demonstration Garden, August 1993.

(132) Action on Waste Division, 1993

(133) *op. cit.* City of Guelph, May 1993. (Ref: 82)

(134) **Collecting and Composting Food Wastes**, Neil Beesley, BioCycle, October 1992, page 56.

(135) **Composting: Its Role in Industrial Solid Waste Management**, D Mallet & C Bourque, University of Moncton Centre of Research in Sciences and Environment, 1992.

(136) *op. cit.* Elcock, August 1993, Pages 21-23, 25, 30. (Ref: 132)

(137) **Planning a Supermarket Food Waste Management Program: a Case Study**, Mark T Jacob, 1992, Regional Municipality of Waterloo.

(138) **Guide to Agricultural Composting**, Gregory Watson, Commissioner, Massachusetts Department of Food and Susan Tierney, Secretary, Agriculture and Executive Office of Environmental Affairs, July 1992.

(139) **Agricultural Composting Handbook**, Ministry of Agriculture, Fisheries and Food, Province of British Columbia, January 1993.

(140) **On-Farm Composting handbook, Document No NRAES-54**, Robert Tynk (Editor), Northeast Regional Agricultural Engineering Service, Cooperative Extension, Ithaca, NY, June 1992.

(141) *op. cit.* Watson and Tierney, 1992, Pages 27-32. (Ref: 138)

op. cit. Glenn, September 1991, Page 32. (Ref: 127)

Composting in Ontario Government Facilities, Green Workplace, Management Board Secretariat, Toronto, Spring 1993.

(142) *op. cit.* Otten and Gibson, University of Guelph, May 1993. (Ref: 65)

(143) *op. cit.* Procter & Redfern *et al.* June 1993, Pages 11-13. (Ref: 121)

(144) **Source Separation and Composting of Organic Municipal Solid Waste**, Mark Gould, Richard Garrison & Stephen Foster, Resource Recycling, july 1992, page 36 *et sec.*

(145) *op. cit.* Taylor, January 1993. (Ref: 38)

(146) *op. cit.* Platt and Morris, January 1993 (Ref: 46) Cited from the Boston, Massachusetts Department Environmental Protection, July 1992.

(147) **Compost ... for Eath's Sake**, the Audubon Society of New York (no date).

(148) *aei* Consultants of Richmond, Ontario and Powell River, BC, Richard Cave & Associates of Ontario at the City of Guelph, and the University of Guelph assisting the boroughs in pilot scale trials at Toronto.

(149) Personal communication from C Calvert Parks Canada. The study was by Margaretha Burnett, a Master of Environmental Design Candidate, the University of Calgary. *op. cit.* M Burnett, January 1991. (Ref: 74)

(150) *op. cit.* Glenn and Riggle, May 1991, Page 31. (Ref: 117)

(151) In addition to government sponsored programs, several large commercial entities in Canada such as Shell and Procter & Gamble have funds which can assist a well put together initiative aimed at significant waste reduction on the municipal scale.

(152) *op. cit.* Platt and Morris, January 1993. (Ref: 46)

(153) *op. cit.* Platt and Morris, January 1993, Chart 3, Page 6. (Ref: 46)

(154) **Strathfort Waste Management Authority: Feasibility Study for the Implementation of a Recycling Program Final Report**, GCG Dillon Consulting Engineers and Planners, June 1990.

(155) *op. cit.* Clawson, November 1989. (Ref: 19)

(156) **West Yellowhead Waste Minimization Plan Final Report (Draft)**, UMA Engineering Ltd, Edmonton, Alberta, July 1993, page 27.

(157) *ibid.* Page 15.

(158) *op. cit.* Rynk (Editor), June 1992, Pages 106-113. (Ref: 140)

(159) Such as the ***Sittler 510***, marketed by Valoraction of Quebec (C.P. 892, Sherbrooke, PQ J1H 5L1 Tel: 819 864 7942 Fax: 819 864 7954).

(160) *op. cit.* Pescod (Editor), 1991, Page 129. (Ref: 1)

(161) *ibid.* Page 129.

(162) Private communication from Cattle Canada Ltd and Greenleaf Products Inc.

(163) **Accounting for Carbon Fixation by Alberta's Forests and Peatlands**, Mark Anielski (Alberta Forestry, Lands and Wildlife), July 1992.

Natural Resource Accounting - Monitoring Sustainable Development, Mark Anielski and Terry Zdan (Alberta Environmental Protection), Gary Howe and Dave Watson (Alberta Bureau of Statistics), April 1993.

(164) **The Price of Everything, the Value of Nothing**, The Economist, July 31, 1993, page 63.

(165) Three centres of composting activity are within reasonable reach of Calgary or Edmonton, Seattle, Minneapolis and Guelph. Seattle's climate is so different from that of Alberta that it is less instructive. In one day in the Guelph area it is possible to visit four simple channel systems on the Pos design and two days in the Minneapolis area are sufficient to see representatives of four conventional in-vessel designs, each of about 100 tpd capacity.

(166) **Compost and Healthy Food**, Jerome Goldstein (Editor), BioCycle, July 1993, Page 4.

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